EXPERIMENT STATION COMMITTEE

1952 REPORT

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

1952 REPORT

THE COMMITTEE IN CHARGE of THE EXPERIMENT STATION

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

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On the cover:
Sugar crystals

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3 JUN 1953

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To The President and Members

HAWAIIAN SUGAR PLANTERS' ASSOCIATION

Gentlemen:

Your Committee takes pleasure in submitting the report of the Director of the Experiment Station, Hawaiian Sugar Planters' Association, for the year 1952. It is our belief that you will find that this interesting and encouraging report covers the record of progress and accomplishment of an extensive research program planned for the most urgent needs of our sugar industry.

Careful screening of authorized research projects has made it possible to give direction to a program in which essentiality and promise of success have been dominant factors.

Some of the noteworthy events and developments this year are set forth below.

The sale of the land and buildings at the Samoa Substation was accomplished early in the year. Testing of our most promising cane varieties for susceptibility to Fiji disease and downy mildew in Fiji through an agreement with, and under the auspices of, the Colonial Sugar Refining Company, is functioning satisfactorily.

The fishpond and surplus surrounding land adjoining the quarantine station at Mapulehu, Molokai, were appraised and sold.

Arrangements were completed with Hawaiian Electric Company whereby a license was granted to construct a power transmission line through the Manoa Arboretum. Careful planning as to location and restrictive measures enforced were instrumental in holding damage to a minimum in this area.

Noteworthy in the work of the Agricultural Engineering Department has been the design and construction of an infield transportation unit, which has gained wide acceptance amongst plantations where heavy rainfall has created a serious problem.

Effective work has been accomplished by the Department of Agronomy in its studies of soils and the better control of irrigation water through various techniques, including the use of radioactive materials. Cooperative studies with the Department of Physiology and Biochemistry in the absorption of plant nutrients through the cane foliage have produced rather significant data.

The field of exploration, covered by the By-Products Committee under the coordination of Mr. George Aljian, has been expanded. The methods by which separation of pith from fiber in sugar cane bagasse can be accomplished have been practically determined. It has been found that pith-molasses mixtures can provide a substitute in part for imported mainland carbohydrates in livestock and poultry rations. The most promising results have been

derived from pulping of bagasse for the production of 9-point corrugated board in which cooperative experiments have been initiated with commercial producers to investigate the possibilities further. Arrangements have also been concluded with a large west coast paper company to investigate the technical aspects of producing high-grade pulps from Hawaiian bagasse. The extremely important work in the By-Products field has been conducted aggressively and effectively and much credit is due to Mr. Aljian and those functioning under him for the progress made.

We wish to record our appreciation for the attendance of the Island members of the Experiment Station Committee and its technical Advisory Committees, and the interest manifested by those members in presenting the problems of the individual plantations. This Committee also wishes to commend the work of the Agricultural Engineering Committee, the Factory Engineering Committee, and the By-Products Committee in the development of their respective programs of scientific research conducted by the Station.

In presenting this report from Dr. Baver and the members of his staff, we feel that it constitutes a record of accomplishment in the field of scientific research and the practical application of the fruits of this research, which has contributed in the past and will continue to contribute in the future in large measure to the prominence and security of the Hawaiian sugar industry.

Respectfully submitted,

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From the Station Director

TO THE EXPERIMENT STATION COMMITTEE

Gentlemen:

Submitted herewith is the Annual Report for the year ending September 30, 1952.

The year 1952 has been characterized not only by plantation adoption of many of the outstanding research developments of the Experiment Station, but also by the uncovering of basic information that has much future significance for the industry.

The work of the Department of Agricultural Engineering was more or less climaxed in 1952 by the almost universal adoption of the infield transport unit by the Hilo Coast plantations. It has been shown that this unit will transport cane from the field without material damage to the soil at rather economical costs. The cane salvager at Kohala Sugar Company has proven successful and efficient in removing shorts from trash at the mill. A cutter-only for irrigated cane made its initial runs at Kahuku and Olokele and gives promise of success when the necessary modifications have been made. The cane harvester built at Kekaha Sugar Company also made satisfactory initial runs. The cutterbar, which was the first cutting unit designed by the Experiment Station, has been coordinated with the push rake at Kaiwiki Sugar Company, where it has done a very creditable job.

The basic work done by the Department of Agronomy on the phosphate problem of the Hilo Coast has resulted in a careful checking of the soils of that area and in applications of phosphatic fertilizers according to prescribed recommendations which have resulted in outstanding cane growth. There has been a significantly increased interest in soil improvement to provide a seed bed for the cane plant which will permit greater root development and consequently higher yields. The studies on soil compaction, both in the wet and the dry areas, have caused management to take preliminary steps toward the correction of poor soil tilth resulting from use of mechanical equipment which has caused decreases in cane yields. Irrigation research has pointed out the need for more adequate control of irrigation water. It is significant to note that thousands of acres of land are now under experimental irrigation control, using the plaster of Paris blocks. In addition, thousands of acres continue under control with the use of tensiometers. The use of radioactive materials to study water distribution is calling attention to the need for more careful planning in the distribution of water.

The Department of Physiology and Biochemistry, in cooperation with the Department of Agronomy, has obtained valuable data on the absorption of plant nutrients through the leaves. Most significant results were obtained in the controlled temperature greenhouses where it was shown that the absorption of nutrients and the growth of the cane were primarily dependent upon root temperature rather than upon air temperature.

The Department of Climatology was combined with the Department of Meteorology to integrate the activities in these closely related areas. Considerable work has been done in meteorology during the past year obtaining basic facts for cloud seeding experiments.

Activities in by-products research were on an enlarged scale. Cooperative work with the Hawaii Agricultural Experiment Station and with local producers of beef, dairy products, and hogs, definitely indicated that pith-molasses mixtures can be substituted for part of the imported mainland carbohydrates in livestock and poultry rations. This information is of particular significance in helping to make the Islands more self-sufficient in the feeding of livestock and poultry. The economics of shipping these mixtures to the mainland were found to be unsatisfactory because of freight rates and other factors. Likewise, an economic study of shipping Hawaiian bagasse to the West Coast for animal litter showed that it could not compete with similar litter shipped into the same area from Louisiana, because of differences in freight rates.

Cooperative work done with the Northern Regional Research Laboratory at Peoria, Illinois, involved our sending two men to Peoria to work with the Agricultural Residues Research Division there. One spent full time with the laboratory men working out a satisfactory method for separating the pith from the fiber. The other was involved in pulping of bagasse for the production of 9-point corrugated paper. In addition to the separation work at Peoria, our local by-products research men studied the problem at the Waipahu pilot plant. Results obtained from both sources have been such that it is now felt that the separation work can be considered practically completed. The pulping work at Peoria was culminated by test runs of Hawaiian bagasse at the School of Forestry, University of Syracuse. The results were promising. Cooperative experiments made with the Flintkote Company of Hilo and Los Angeles on the production of 9-point corrugated board from bagasse more or less confirmed the findings at Syracuse that satisfactory container board can be made from bagasse. The economics of the process are now under investigation.

Formal arrangements have been made with a development laboratory of a large west coast paper company to investigate the technical aspects of making high grade pulps from Hawaiian bagasse. Our man from the by-products project who was stationed at Peoria in 1952, will be moved to the West Coast to assist in this work. With the completion of the separation work at Peoria and the contract with the development laboratory of the west coast paper company for evaluating pulping techniques, the formal cooperative work with the Northern Regional Research Laboratory will be terminated as of November 1, 1952. Informal cooperation will be maintained.

There were several developments in the patent field with Station personnel. These involved applications for patents on a process for separating the pith from the fiber of bagasse, on the development of a TCA corrosion inhibitor by the Department of Chemistry, on certain features of the infield transport unit developed by the Department of Agricultural Engineering, and on a new and novel idea for integrating temperature and sunshine by the Department of Physiology and Biochemistry.

The Library added a total of 987 volumes during the year, of which 37 were gifts. Outside borrowers from the Library have been on the increase, including students from the University, business houses, shipyards, plantation staff, and others.

Staff changes that took place during the year will be found on page 76.

Respectfully submitted,

EXPERIMENT STATION, HSPA

By L D Baver

L. D. Baver
Director

BY-PRODUCTS

MOLASSES VALUE MAJOR COST FACTOR IN YEAST PROTEIN

Although pilot plant experiments at the Experiment Station succeeded in cutting chemical costs approximately in half, yeast production from molasses could not compete with imported protein from soybean meal unless the price of molasses fell to around $10.00 per ton. A very good grade of yeast containing 52 per cent protein was made. Chemical costs were reduced by substituting sulfuric for phosphoric acid. Operating costs were improved by decanting instead of filtering the clarified wort. Sufficient information has been gathered to permit construction of a full-scale yeast plant whenever economic conditions may warrant it. The total operating costs may be summarized as follows:

Chemical costs	$0.040	per pound of protein
Antifoam	$0.010	" "
Utility costs	$0.013	" "
Fixed plant costs	$0.019	" "
Labor costs	$0.022	" "
Molasses costs		
at $40/ton	$0.220	" "
at $20/ton	$0.110	" "
at $10/ton	$0.055	" "

It should be remembered that these costs are calculated on the protein content of the yeast only and do not include the value of the large amount of the Vitamin B complex present.

FEEDS FROM SUGAR CANE BY-PRODUCTS LOOK PROMISING IN THE ISLANDS

Cooperative feeding experiments made with the Hawaii Agricultural Experiment Station and with local beef, dairy, and hog producers during 1952, have indicated that the pith of bagasse can be used as a carrier for both blackstrap and B molasses to substitute for a part of the imported mainland carbohydrates in livestock and poultry rations. Experiments at the University of Hawaii on dairy heifer and steer feeding have shown that while the pith of bagasse is a low-nutrient feed, it is an excellent carrier for molasses. Mixtures containing as much as eight parts of molasses to one of pith have remained friable under island conditions. This fact makes possible the production of a dry molasses feed that can be bagged. These experiments have also shown that the way the pith is prepared is unimportant for ruminant animals. Dry-screened pith was just as good as wet-screened. Predigested pith was no more efficient than undigested. The steers and heifers did not make the daily gains that were expected, and so experiments with feeding rations containing more molasses per pound of pith are now in progress.

An experiment, made in cooperation with Moanalua Dairy in which 26 per cent of the ground milo in the ration was replaced with a mixture of five parts of molasses to one of pith, indicated that milk production decreased only two per cent, which is well within the limits of experimental error. The cost of producing the milk with the bagasse-molasses substitution was also slightly lower than with the usual ration.

Substitution of a five-to-one molasses-pith mixture for grain in a commercial ration used for growing pigs at the farm of Thomas Kakazu, resulted in about the same rate of gain as was given by the control ration. Experiments with pigs at the Hawaii Agricultural Experiment Station indicate that B molasses can be substituted for the barley in the ration up to the point where there is 40 per cent B molasses in the ration. The pigs receiving the B molasses showed greater gains than those fed the control ration.

Experiments with low-grade sugar in the rations of laying hens at the Hawaii Agricultural Experiment Station have shown no real difference in

the body weight of hens fed sugar-bagasse mixtures as compared with mainland grains. Although the efficiency of feed conversion was decreased slightly with the sugar ration, the experiments definitely show that sugar-bagasse mixtures can be used as an emergency source of carbohydrates in case there should be restrictions on the importation of mainland feeds. Best results were obtained when only 50 per cent of the cereal grains were replaced with sugar-bagasse mixtures.

ECONOMICS AGAINST MAINLAND MARKET FOR MOLASSES-PITH FEEDS

Freight costs make the possibility of shipping molasses absorbed in bagasse pith rather doubtful. The dry-molasses product must always sell at a higher price than liquid molasses. This will automatically restrict the use of the molasses-pith mixtures on the Mainland to specialty products of limited volume.

HIGH FREIGHT RATES ELIMINATE HAWAIIAN BAGASSE FOR MAINLAND ANIMAL LITTER

Although a complete technical analysis has shown that excellent animal litter can be produced from the coarser fractions of Hawaiian bagasse, the economics of producing such litter in the Islands was shown to be governed entirely by freight rates. Freight rates from the Islands to the West Coast are about 86 per cent higher than rail freight from Louisiana to California.

FIBER-PITH SEPARATION METHODS APPROACH COMPLETION

Cooperative research done with the Northern Regional Research Laboratory at Peoria, Illinois (Figure 1), together with investigations made at the Waipahu pilot plant, indicate that both wet and dry methods for separating the pith from the fiber of bagasse can be made relatively simple and can be brought within the range of economic feasibility. Feeding experiments with cattle have shown that dry-screened pith is adequate. The degree of pith separation required for satisfactory paper making must await the completion of research presently under way to establish the effect of pith on the physical characteristics and the cost of production of paper pulp. (Figure 2)

Figure 1. This picture of the Northern Regional Research Laboratory, USDA, located in Peoria, Illinois, where investigations on methods for separating the pith from the fiber of bagasse have been carried on during the past year, is shown by courtesy of the Laboratory.

Figure 2. The Jonsson screen is used to separate the pith from bagasse fiber. Here R. L. Brown, HSPA, is adjusting the flow to the screen. Courtesy Northern Regional Research Laboratory, USDA.

CORRUGATED BOARD FROM BAGASSE LOOKS ENCOURAGING

Cooperative tests made with the Northern Regional Research Laboratory and with the Flintkote Company of Hilo and Los Angeles, are now in progress to establish both the technical and the economic possibilities of making 9-point corrugated board from bagasse. Preliminary data and observations warrant continuing the study to include shipping tests and to obtain other related information on the strength and wear of containers made from this board. Definite information on this phase of the pulping work should be available by the middle of 1953.

PULPING HAWAIIAN BAGASSE STUDIED ON WEST COAST

A formal working agreement has been completed with the Crown Zellerbach Corporation at Camas, Washington, to use their research facilities to investigate the pulping characteristics of Hawaiian bagasse with special emphasis on the production of high-grade pulps. Investigations are covering the determination of the basic pulping characteristics of different varieties, methods of pulping, evaluation of proprietary processes, and related problems, in order to establish the pros and cons of paper making from bagasse. It is anticipated that this arrangement will provide many of the answers to questions concerning pulps from bagasse.

CANE WAX VARIES IN ISLAND FILTER CAKES

Cane wax extraction studies presently under way on factory filter cake show the average crude wax content for the Islands to be 6.77 per cent. Crude wax yields varied quite widely from factory to factory and island to island; for example, the crude wax content of factory filter cakes on Kauai varied from 4.58 per cent to 11.75 per cent, on Oahu from 5.88 per cent to 8.29 per cent, on Maui from 6.07 per cent to 9.95 per cent, and on Hawaii from 2.64 per cent to 10.54 per cent.

Based on the available analytical data, there is an average of 1.5 pounds of recoverable crude wax in our filter cake per ton of net cane milled. In many instances, however, recovery is not economically feasible due to the low concentration of wax in the filter cake.

CULTURAL PRACTICES

SPOTTING N IN THE PLANT WITH TRACER TECHNIQUES

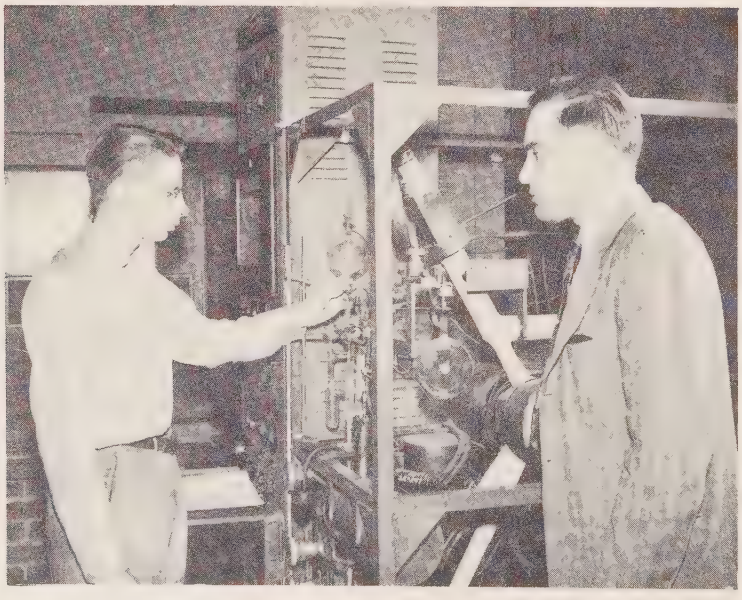
Under an arrangement with the University of Minnesota, the Department of Physiology and Biochemistry is conducting cooperative work on nitrogen metabolism of sugar cane with N 15. There being no radioactive isotope of this important element available, heavy nitrogen must serve as a tracer. Its use requires the very expensive and complicated mass spectrographs. The instrument used for HSPA analyses is the special recording type shown in Figure 3, with its inventor, Dr. Alfred O. C. Nier, and John Saari, graduate student in physics.

The first sample of N 15 from sugar cane was sent to Minnesota on March 31, 1948. Since then, hundreds of samples have given a better understanding of the use of nitrogen by sugar cane. New nitrogen moves rapidly from the roots to all parts of the plant, and old nitrogen is in a continual state of flux, circulating from primary to suckers and back again.

During the past year, two interesting experiments have been completed. The first compares the utilization of newly fed nitrogen by nitrogen-rich and nitrogen-deficient plants. Figure 4 shows that the two types of plants make very different use of the new soluble nitrogen. Whereas the well-fed plants enrich chiefly the roots and the 8–10 internodes of the stalks, the starved plants enrich chiefly the basal joints and the growing tip. There seems to be a strong tendency to maintain high levels of soluble nitrogen in the basal joints.

The second N 15 experiment of special interest was done in cooperation with the Agronomy Department. Heavy urea synthesized by the du Pont

Figure 3. The Nier recording mass spectrograph is shown here with Professor Alfred O. C. Nier, its inventor, and John Saari, graduate student in physics who receives an HSPA fellowship.



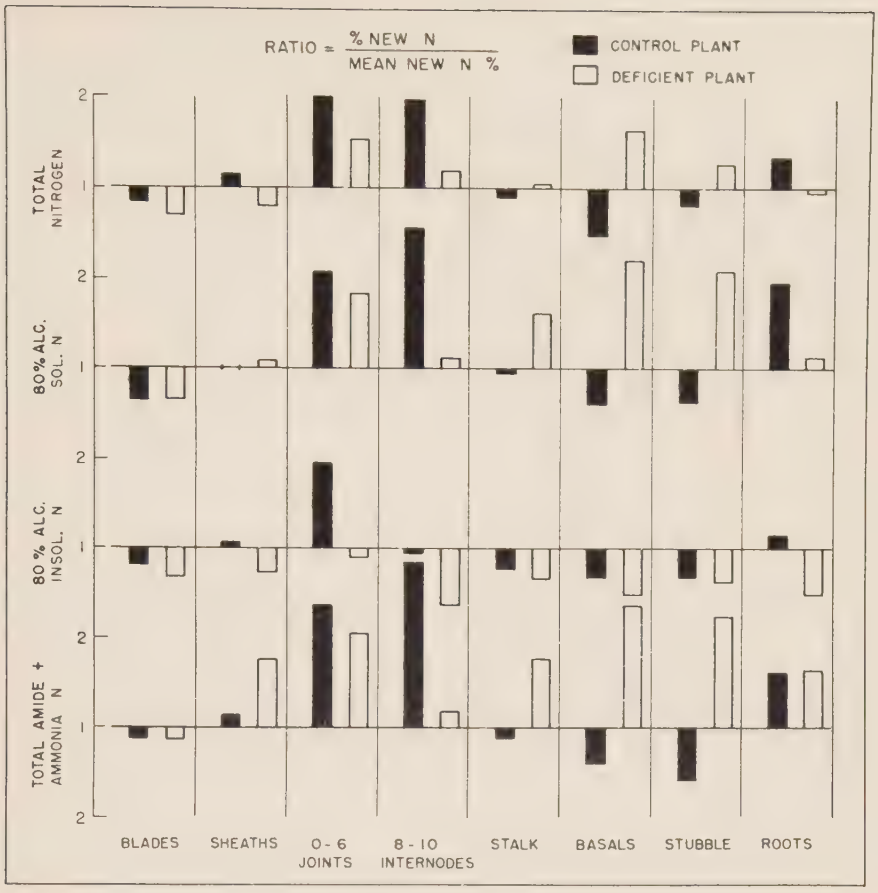


Figure 4. New nitrogen fed as N15 ammonia via the roots in culture solution shows large differences in distribution in well-fed and deficient plants. The maxima and minima of new soluble nitrogen are in widely different anatomical regions.

Figure 5. In spraying a large sugar cane plant with heavy urea, the plastic bag traps the spray which does not strike the plant and keeps it from running down the stalk into the culture solution.

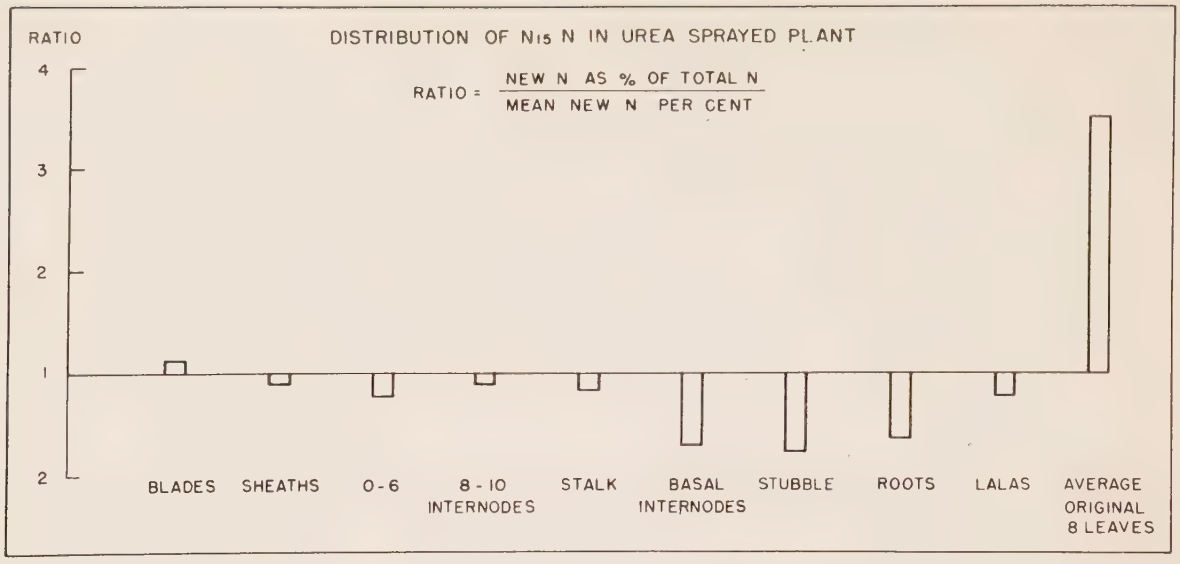
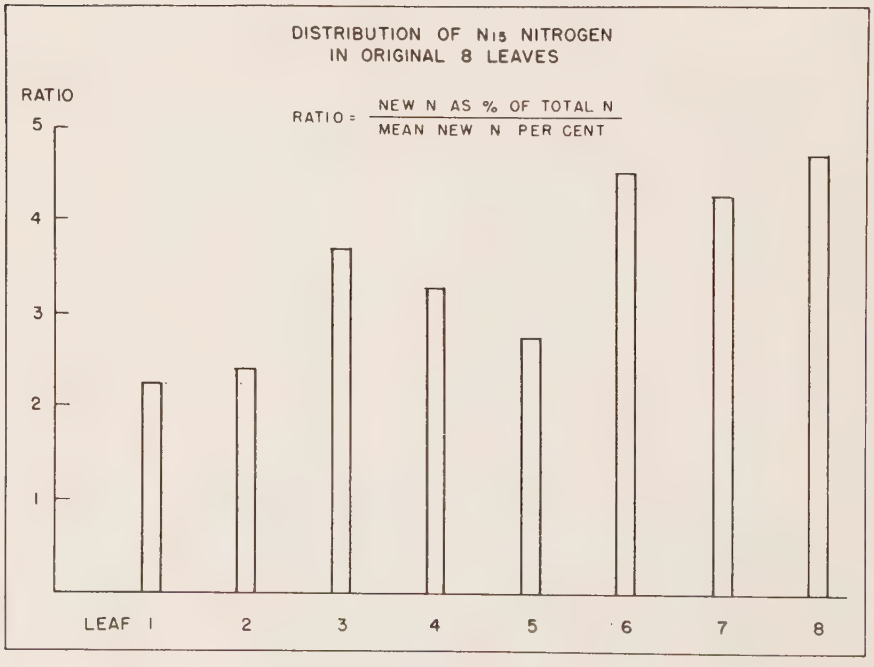


Figure 6. Distribution of nitrogen from tagged urea eight weeks after spraying. The columns show the deviation of each plant part from the average enrichment of the entire plant. For example, the original leaves were about 3½ times as rich as the plant average, and the stubble was about half as rich.

Figure 7. The older sprayed leaves retained about twice as much urea nitrogen as the top leaves at time of dropping.



Company was sprayed on the leaves of a sugar cane plant growing in standard culture solution (Figure 5). The plant had eight good leaves which received the urea spray. These were gathered for analysis as they aged and dropped off. Eight weeks after spraying, when the plant had grown all new leaves, it was harvested and subdivided for analysis. Figures 6 and 7 summarize the data in a way to compare enrichment of each anatomical part with sprayed nitrogen. The following points are clearly demonstrated:

(1) Most of the enrichment remains in the sprayed leaves, with the highest amount in the older leaves.

(2) The growing tip and the new leaves received a very small percentage of nitrogen from the urea. The actual value for the new blades is 4.65 per cent of their nitrogen from sprayed urea. This value is hardly detectable by present methods of sampling for leaf punch nitrogen and explains why an increase observed immediately after spraying has disappeared four weeks later when four new leaves are being sampled.

(3) Sprayed nitrogen makes up a very small percentage of the total in basal internodes and roots of a well-fed plant.

RADIOACTIVE PHOSPHATE ANSWERS MANY QUESTIONS

The Departments of Agronomy and of Physiology and Biochemistry, in cooperation with seven plantations, installed nine experiments in which superphosphate and ammonium phosphate fertilizers tagged with P32 were placed with the seed. About three months later the cane was harvested, analyzed for phosphate and the radioactivity counted.

Five of the nine experiments were installed to determine the utilization of fertilizer phosphorus in (1) soils that are adequately supplied with available phosphorus and (2) soils that are deficient in available phosphorus. Radioactivity counts taken at monthly intervals showed that the response from superphosphate was generally about double that from ammophosphate. The two sections of each plot of all experiments having received the radioactive phosphate fertilizers were harvested, and the leaf, stalk, and root samples are being analyzed.

Cane yields at harvest are represented by the three parts of Figure 8. Each column represents the mean weight of ground leaves (blades), stalks

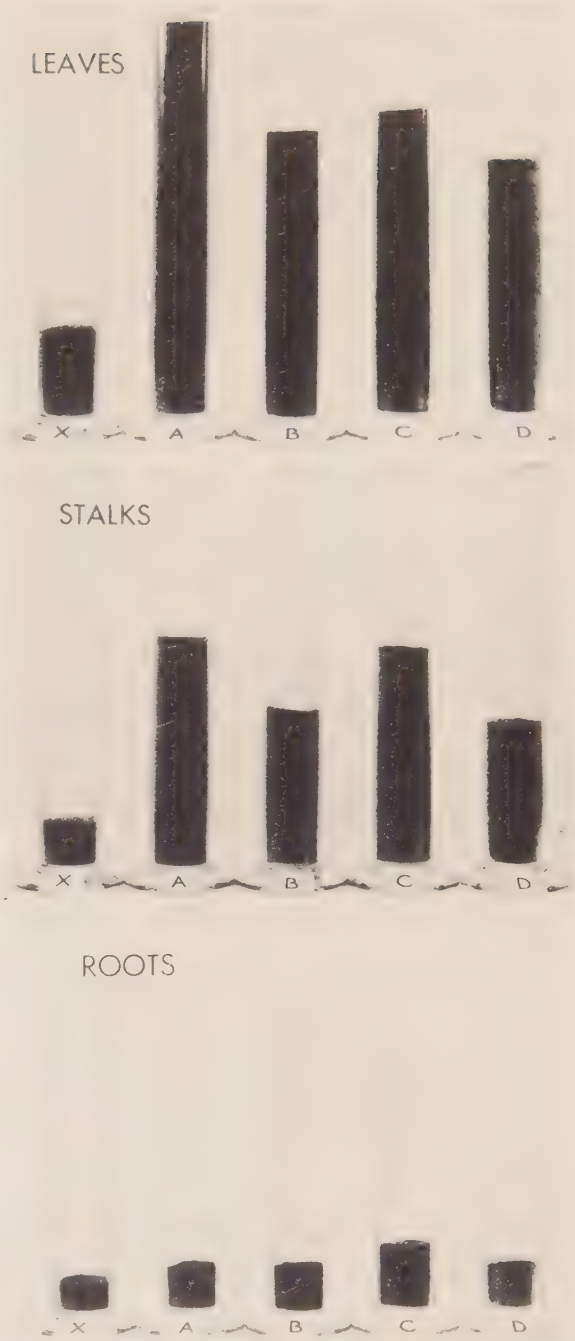


Figure 8. The top picture represents volumes of ground leaf samples, the middle picture represents ground stalk samples, and the bottom picture represents ground root samples, all from Hakalau Experiment 124 AxFP. X stands for the check; A for the application of 200 pounds per acre of superphosphate; B for the application of 200 pounds per acre of ammophosphate; C for the application of 400 pounds per acre of superphosphate, and D for 400 pounds per acre of ammophosphate.

and roots for Hakalau Experiment 124 AxFP. In this soil that, at 11 ppm, was deficient in available phosphorus, marked increases in yield were obtained with phosphate fertilization. It is of interest to note that response was obtained both in the above-ground portions of the cane plant and in its root systems. Root surfaces would have given a better picture of response since the root systems of the treated plots were fibrous and obviously active when compared to the thick, stubby roots of the check plots.

The other four of the nine experiments were installed to check the utilization by ratoon crops of fertilizer phosphorus placed on the surface and in subsurface positions. Under continuously wet soil conditions, when the root systems extend to the surface, phosphorus placed on the surface is utilized. Under irrigated conditions, when alternate wetting and drying prevents the root systems from extending to the surface, it is doubtful if significant responses are obtained from fertilizer applied on the surface. The only test made under irrigated conditions was in Oahu Sugar Company soils adequately supplied with available phosphorus. Consequently, little response was obtained from the fertilizer phosphorus.

NEW PLANTS GET FOOD FROM SEEDPIECE

Young stalks of 37–1933 were made radioactive by feeding P32 through the culture solution. After thorough assimilation of the new phosphate, the following experiments were done:

1. Ten single-eye seedpieces were cut from one stalk. Two were killed immediately for controls while the other eight were planted. Three months later the following average distribution of the phosphate was found:

Spindle	17.33%
Leaf blades	32.92%
Sheaths	7.93%
Stalks	7.18%
Roots	15.48%
Suckers	3.99%
Remaining in seedpiece	15.88%

2. The second cane stalk was cut into five 2-eye seedpieces. One was planted with both eyes intact, two were planted with the lower eye removed, and two with the upper eye removed. After three months, the plants were harvested and the residual seedpieces sectioned. The results are shown in Table 1.

These two experiments emphasize the importance of having seedpieces rich in stored food. The following conclusions may be drawn:

(1) About 85 per cent of the phosphate in the seedpiece is taken into the new plant and distributed generally throughout all tissues.

(2) As much phosphate can be absorbed from the whole seedpiece by either the upper or the lower eye as by both eyes together.

(3) When adjacent eyes germinate, the two plants compete for the stored phosphate and neither is as rich as single plants.

TABLE I

PHOSPHATE ABSORPTION FROM SEEDPIECES

Seedpieces are numbered from base to top of cane plant and growing eyes are identified as either upper or lower.

	#1 Lower	#2 Upper	#3 Lower	#3 Upper	#4 Upper	#5 Lower
Dry Weight of Plants	88.5 g.	93.5 g.	57.5 g.	63.0 g.	95.5 g.	94.5 g.
Per cent of P32 absorbed by plant*	82.8	81.4	36.9	48.5	85.1	84.6
			85.4			

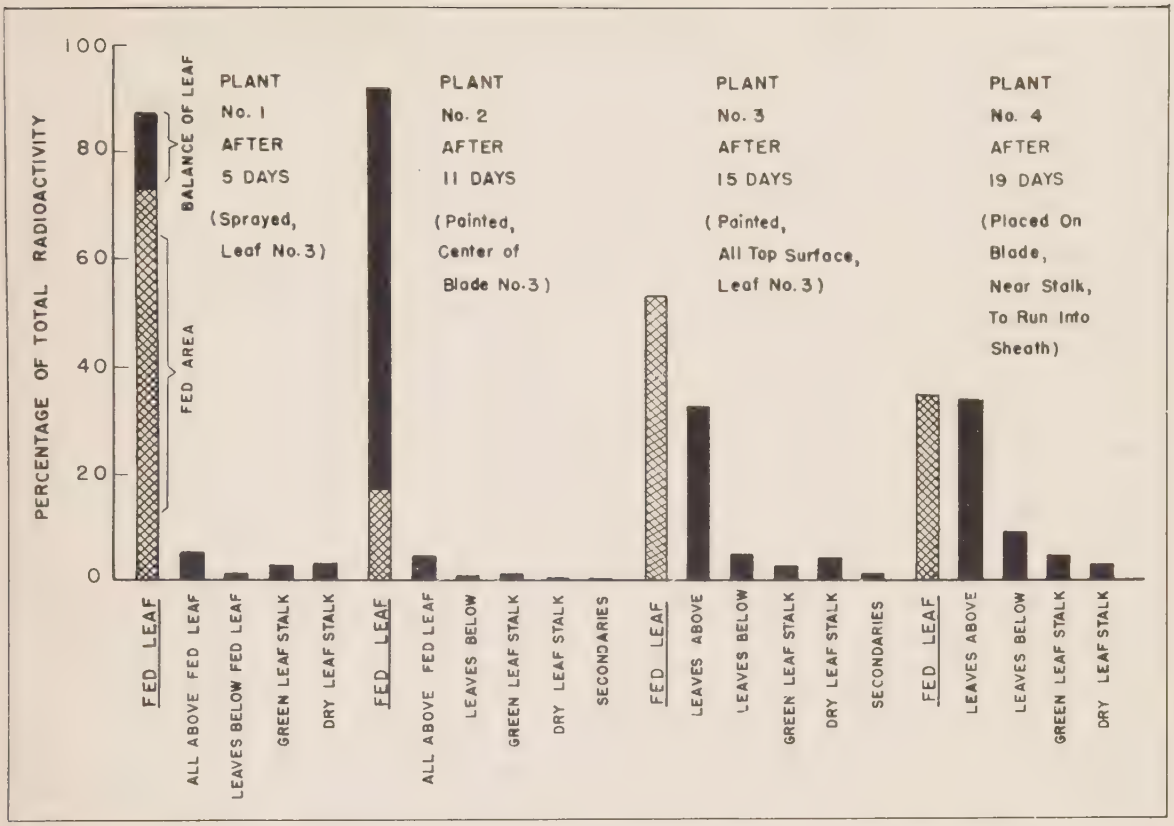


Figure 9. Distribution of radioactive rubidium applied to the cane leaf.

RADIOACTIVE STUDIES SHOW UP LEAF ABSORPTION OF NUTRIENTS

All ions and compounds thus far tested are known to enter the leaf to some extent and to be partially translocated to all parts of the plant. Some of the inorganic elements move in very slowly and considerable time must be allowed for general distribution throughout the plant. The two elements studied in detail this year were radioactive phosphorus and rubidium.

Rubidium 86: This element was chosen as a close relative of potassium, whose radioactive form (K 42) has a half-life of only 12 hours and is of limited usefulness in studies with sugar cane. Rubidium has been shown to have some similarity to potassium physiologically. Figure 9 illustrates the distribution of Rb 86 after a solution had been sprayed or painted on leaves of young cane plants. Two points are clearly made:

(1) About 19 days are required for translocation of 65 per cent of the ion from the area of application.

(2) Most of the translocated material goes to the leaves above the treated leaf.

Phosphorus 32: In an experiment made cooperatively by the Departments of Agronomy and of Physiology and Biochemistry, three potted cane plants enclosed in cages were each sprayed with 1 mc. of P32. Plant No. 1, which did not receive added carrier phosphate in the spray, was harvested 20 weeks later. Plants No. 2 and No. 3 each received 480 mg. P_2O_5 in the spray along with their dose of 1 mc. of P32. These plants were harvested 15 weeks later. The phosphate was in the form of potassium dihydrogenphosphate.

At the time of harvest, all leaves that had received the spray had dried so that all green leaves growing at time of harvest had developed after the plants were sprayed. "Dry leaf stalk" samples were washed at time of harvest to eliminate active material that was sprayed on the outside surface. Results are summarized in Table II.

TABLE II

Distribution of P32 in Cane Plants 15-20 Weeks After Spraying

Samples	Dry Weights (gm)	Radio Activity counts/min/gm.	% of total
Plant No. 1 (1 mc. P32 in spray)		x 10^3	
Dry leaves (received spray)	160.9	17.2	55.52
Older green leaves	72.0	7.0	10.11
Spindle + 3 top leaves	51.2	11.6	11.92
Dry leaf stalk	246.4	2.4	11.86
Top stalk	57.8	7.4	8.59
Suckers	17.9	5.6	2.00
Plant No. 2 (1 mc. P32 + 480 mg. P502 in spray)			
Dry leaves (received spray)	51.4	21.6	53.55
Older green leaves	37.5	7.8	14.08
Spindle + 3 top leaves	34.2	12.0	19.78
Dry leaf stalk	181.2	1.0	8.73
Top stalk	16.6	4.8	3.86
Plant No. 3 (1 mc. P32 + 480 mg. P502 in spray)			
Dry leaves (received spray)	63.3	21.7	56.85
Older green leaves	36.8	5.6	8.52
Spindle + 3 top leaves	30.7	12.2	15.52
Dry leaf stalk	212.1	1.7	14.89
Top stalk	12.9	2.4	1.28
Suckers	19.2	3.7	2.94

These data show clearly that over half of the phosphate retained by the plants for a period of 15 weeks remained in or on the sprayed leaves. About 45 per cent was generally distributed throughout the plant, and the very young new leaves were half as rich in sprayed phosphate as the sprayed leaves had been when they dropped, indicating very good utilization of sprayed phosphate.

TABLE III

Specific Activities of Phosphorus Fractions in the "Water-Soluble Neutral, Pectin-Free, Barium-Insoluble Precipitate"

Section Rf	Tentative Identification	Specific activity as c/m/m	
		Entire section counted	Isobutanol counted
.00–.03	Unknown	184,166	108,064
.03–.07	Fructose diphosphate	147,857	133,333
.07–.09	Adenosine triphosphate	86,250	84,705
.09–.18	Glucose-1-phosphate—Glucose-6-phosphate	190,000	119,523
.18–.24	Fructose-6-phosphate	190,000	118,518
.24–.40	Phosphoglyceric acid	264,285	220,000
.40–.60	Inorganic phosphate (ortho)	254,508	298,304
.60–1.00	Unknown	112,727	31,000

RADIOACTIVE PHOSPHATE HELPS TO UNDERSTAND THE CANE PLANT

Because of the great importance of phosphates in intermediary metabolism, a concerted effort is being made to get more detailed knowledge about these compounds in the sugar cane plant. The most modern tools, including chromatography and tagging with radioactive elements, have been used.

Definite progress has been made in the identification and quantitative estimation of many of these complex substances. For example, a young cane plant with many mature joints was fed a rich dose of P32 via culture solution. One week later, it was harvested and the distribution of P32, shown in Table III, was found. The Rf values show the relative position of the compounds on a paper chromatogram, and the specific activities show the relative richness of the compounds in the new phosphate fed one week earlier. Two methods of counting are compared. It is evident that phosphoglyceric acid is so directly in the metabolic cycle that it quickly attains the value for inorganic phosphate, while only one-third of the adenosine triphosphate has entered the cycle during the week.

REFINEMENT OF CROP LOGGING TECHNIQUES IN PROGRESS

Crop logging, a guide in the growing and ripening of sugar cane, is being practiced over an increasing acreage of caneland. During the past year, considerable time and effort have been expended in revising and amending existing crop log procedures. A photoelectric colorimeter has supplanted color standards in the determination of nitrogen in leaf blade and leaf punch samples, and it is also employed in the determination of phosphorus in leaf sheath specimens. The use of this instrument in these two procedures enables the analyst to handle a larger number of samples with a greater degree of accuracy and precision.

In the revised procedure for the determination of total sugars and potassium in cane leaf sheath material, sugars and potassium are extracted and sugars are inverted without the use of heat. Potassium in the extract may be determined either by the cobaltinitrite method or on the flame photometer.

FLAME PHOTOMETER—NEW TOOL IN PLANT AND SOIL ANALYSIS

Used for the determination of potassium in extracts of soil and plant tissue and in water specimens, the Perkin-Elmer flame photometer has proved to be exceedingly efficient and accurate instrument.

Two identical units are now in service in plantation crop log laboratories. In each case, a staff member of the Chemistry Department has instructed the plantation personnel in its maintenance and operation.

EXCHANGEABLE SOIL POTASSIUM ANOTHER GUIDE TO PROPER POTASH FERTILIZATION

Field experiments and, more recently, crop logging have defined the need for potash fertilization of sugar cane. Soil analyses from the check plots of 26 Grade A experiments have shown that response may be expected at levels below about 75 ppm potassium. Response has not been observed at levels above 100 ppm. In the intermediate range, from 75 to 100 ppm response is variable and potash fertilization is recommended for insurance purposes.

CALCIUM AND MAGNESIUM NUTRITION GAINING PROMINENCE

Interest in calcium and magnesium as essential nutritional elements is increasing as it grows more and more apparent that under certain conditions they are becoming limiting factors of growth. The balance of these elements with the others necessary for plant growth is indicated as one cause of leaf freckle and other nutritional disorders.

Figure 10 represents the response that is being obtained on the highly leached, acid mauka soils of the Hilo Coast. The foreground is a check plot in Pepeekeo's Experiment 83 APxCa. The plot in the background received 580 pounds of calcium. Preliminary data suggest that the critical level for exchangeable soil calcium lies in the vicinity of 50 ppm calcium. The check plot in Figure 10 has 5 ppm calcium.

Figure 10. The highly leached, acid mauka soils of the Hilo Coast are responding to treatments with calcium. In the foreground is a check plot in an experiment at Pepeekeo. The plot in the background received 580 pounds of calcium.

SPECTROGRAPHIC ANALYSES DETECT IMPROPER BALANCE OF NUTRIENTS

The spectrograph is proving to be a valuable tool in detecting improper balance of nutrients in sugar cane. This year, approximately 150 samples have been analyzed for all the inorganic elements known to be essential for plant growth. Work is progressing to increase the accuracy of the analyses.

Some deficiencies manifest themselves in stunted growth, and others are represented by freckling of leaves and by other symptoms of distress. The following example presents the data accumulating from freckled and non-freckled cane from Field 40, Grove Farm Company.

These data show that freckled cane has an accumulation of potassium that cannot be used to produce more cane and sugar as long as calcium and magnesium remain as limiting factors of growth.

An AC arc source and a new densitometer have been constructed for the spectrograph in order to make quantitative chemical analyses possible. A backlog of information is being built up on the time element composition of normal and deficient cane. These data should prove useful in the diagnosis of nutritional disorders, such as leaf freckle, growth failure, etc.

	Parts per Million										
Samples	Ca	Mg	K	Na	Mn	Fe	Co	Cu	Mo	Zn	Al
Freckle sheaths	520	980	20,000	175	9	105	0.4	24	2.2	100	10
Normal sheaths	1920	2150	16,400	165	63	55	0.5	17	2.8	70	12

AVAILABLE SOIL PHOSPHORUS DETERMINES THE NEED FOR PHOSPHATE FERTILIZATION

The critical level for available phosphorus for sugar cane on normal, deep-phase soil was established at 20 ppm by 37 replicated Grade A field experiments. During the past year, approximately 1,200 soil samples have been analyzed. The results of these analyses have been individually interpreted for guidance in field fertilization.

General and marked response to the recommended applications of phosphate fertilizer, as defined by the HSPA modification of the Truog procedure, can now be observed over thousands of acres of cane throughout Hawaii.

FIELD EXPERIENCE WITH FOLIAR FERTILIZATION VARIES

Foliar fertilization in liquid form has been tested through three years of experiments. Preliminary results indicated that nitrogen, potassium and phosphorus entered the plant through the stomata and were translocated as needed. The results of these tests, based on color changes, plant composition and growth measurements, prompted the expansion from approximately 5,000 acres sprayed in 1951 to over 12,000 acres sprayed this year to date.

Harvested results of replicated experiments have been inconclusive. Some tests have shown significant responses from nitrogen and potash applied by air in the second season. Others have failed to show gains. It is apparent from these tests that when critical shortages exist, supplementary plant food applied in liquid form will be effectively utilized to keep the cane plant growing. Where adequate second-season fertilization has been provided, no response can be expected from the sprayed fertilizer.

Significant responses have resulted for potash sprayed by airplane over substantial applications of potash to the soil in relatively large acreages being fertilized in this manner. An investigation is under way to determine the reasons for the limited utilization of soil-applied potash fertilizer.

Recent developments include the use of duster equipment in the application of dry fertilizer by air. Amounts up to 400 pounds per acre have been applied with satisfactory distribution. Urea, the cheapest source of nitrogen other than anhydrous ammonia, has been produced by the du Pont Company in pellet form, coated so that it remains free flowing. Muriate of potash has also been successfully applied in dry form from the air.

SOIL IMPROVEMENT—MORE SUGAR FROM POORER SOILS

Replicated experiments, in which addition of organic materials to the soil has increased yields up to 2.7 TSA, are responsible for field scale applications on several plantations. The most effective soil conditioner has proved to be 10 to 15 tons per acre of trash or bagasse. Continued studies of the root systems of treated and untreated plots have again shown the advantages of providing the cane plant with proper soil-air-water environment.

The requirements of the microbiological population during the initial stages of decomposition are adequately met by supplementing normal fertilization with six pounds of nitrogen per ton of organic material.

The effectiveness of bagasse in increasing the infiltration capacity of tight soils has made it possible to increase the acre inch application of the irrigations.

SOIL CONDITIONERS PROVE INEFFECTIVE IN PRELIMINARY EXPERIMENTS

Monsanto Chemical Company's soil conditioner, Krilium, has been tested extensively both in the laboratory and in small plot field tests under a wide variety of soil and environmental conditions. Laboratory tests on water stable aggregation, permeabilities, flocculation rates, plastic limits, and moisture tension curves, show no outstanding improvements when Krilium was applied in concentrations of 0.001 per cent to 1.0 per cent.

Field tests with applications ranging from 100 to 2,000 pounds per acre have failed to produce significant responses. Figure 11 represents a "jelled" condition of a Waialua soil that had received Krilium at the rate of 1,000 pounds per acre on the cane line. The seedpieces rotted in a water saturated environment that excluded air.

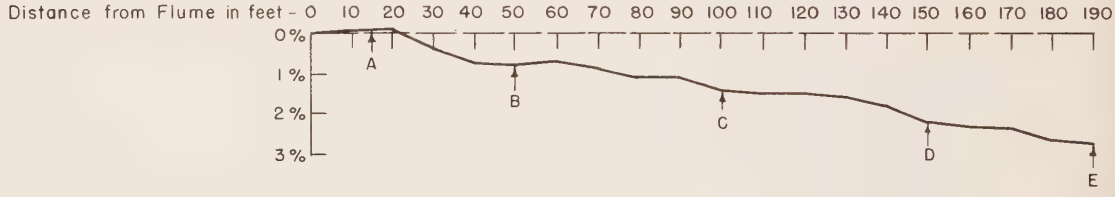
Further testing is planned with Krilium, Aerotil, and other soil conditioners.

Figure 11. Rotting seedpieces in soils treated with Krilium at 1000 pounds per acre. Air was excluded from a water-saturated environment.

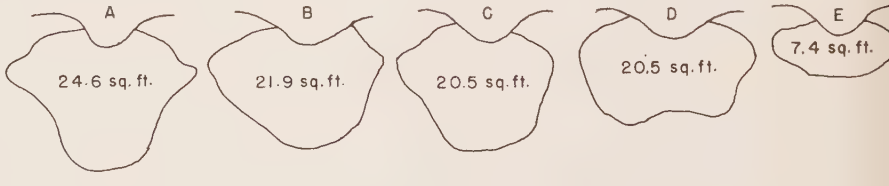
Figure 12. This chart represents the type of data accumulating from irrigation studies of individual cane lines.

IRRIGATION TEST I H.C.& S. CO. FIELD 204

Plant Crop 1st Irrigation (Mauka Line) Herringbone System Soil Type: Low humic latosol, Kohala Family



Per cent Slope	+.3	+.9	-3.7	-4.3	-2	+.8	-1.5	-2.5	-.3	-3.2	-.7	-.2	-.7	-2.3	-4.0	-.8	-.6	-2.8	-.8	+1.6
Water Flow in Minutes	39	38	37	36	35	34	32	31	29	27	25	23	20	17	14	12	8	5	3	0
Field Soil Readings in Micro Ranking / Hour at 3" (Beta and Gamma)	65	40	35	80	35	45	15	30	10	15	25	20	15	15	10	<5	<5	5		
Oven Dry Soil Readings Counts/Minute	1512			894					552					340					180	



Calculated Inch Irrigation	17.5	17.1	11.9	7.2	3.8
Calculated Are Inch Irrigation (14 inch water line) (65 inch width of row)	3.9	3.8	2.6	1.6	0.8

EXPANDED IRRIGATION RESEARCH SHOWS NEED FOR BETTER DISTRIBUTION OF WATER

Cooperative studies made by various plantations, the Island Representatives and the Departments of Agronomy and of Physiology and Biochemistry, using radioactive materials, show an outstanding need for a better distribution of irrigation water.

Radioactive rubidium and phosphorus tests, supplemented by wetting pattern studies through diggings, have emphasized the need for modifications in systems of irrigations, length and slope of line, and speed of water application in many types of soil. Figure 12 represents the type of data accumulating from irrigation studies of individual cane lines.

EXTENDING IRRIGATION INTERVAL TO WILTING POINT DEPRESSES YIELDS

In an irrigation experiment at Waialua, varied irrigation intervals, based on soil moisture determined by plaster of Paris blocks and tensiometers, were compared, and the effectiveness of cane trash mulch for moisture conservation was investigated.

Yields from plots irrigated at 5,000 ohms, when approximately 75 per cent of the available water had been removed, were equal to the field yields. The unmulched 5,000 ohm plots received 23 rounds of irrigation and a total of 68 inches of irrigation water, compared to the plantation practice for the field of 27.2 rounds totaling 153 inches.

It must be pointed out that in the experiment plots, small acre inch applications could be used in short lines and still accomplish the desired wetting of the kuakua. The differences in amounts of irrigation water applied are large, but a part of the differential is due to the fact that water must be applied late in the fall and early in the spring to insure adequate coverage for the entire 9,700 acres in cane. If higher acre inch applications in the fields' long line layout are necessary to insure adequate water penetration at all distances from the flume, then further study in the distribution of water is necessary.

Significant reductions in sugar yields were obtained from the plots irrigated at 75,000 ohms when approximately 97 per cent of the available water had been depleted, and from the plots irrigated at 200,000 ohms which is a point beyond the permanent wilting point for this soil. There was no further significant loss for irrigations extended from 75,000 to 200,000 ohms. The differences in cane tonnage were not proved statistically significant. The reduction from 150 to 135 inches in total water, including rainfall and irrigations, resulted in a significant loss of sugar. It is apparent that proximately 150 inches of water, defined by irrigations at 5,000 ohms, is as close to the breaking point of declining yields as it is possible to go. Under these soil and climatic conditions, it would seem advisable to establish field control at somewhat less than 5,000 ohms resistance. The shape of the moisture tension curve for this soil insures adequate warning from plaster of Paris blocks for the required irrigations.

Applications of cane trash as a surface mulch failed to increase or to decrease yields of cane. Normal yields from the mulched plots at harvest were unexpected, since these plots were obviously depressed during the first season's growth.

During the early history of the crop, all plots received the same irrigation treatment. Because the surface mulch held excessive moisture around the germinating seed and the young plants, germination was poor and heavy replant was necessary. The chopped cane trash did not impair the distribution of irrigation water. As soon as the cane closed in, the effectiveness of the mulch in reducing evaporation and in lengthening the irrigation interval was no longer apparent.

Evaporation rates from a free water surface fell to very low levels in November and December of 1950, when irrigation was not needed. They rose gradually in the spring of 1951 to reach a peak in July when the "A" plots required their most frequent irrigations. They fell again in the winter months starting with December, just after the experiment entered its ripening period. Evaporation from a free water surface appears to have some promise in estimating the water requirements of sugar cane.

THOUSANDS OF ACRES UNDER IRRIGATION CONTROL WITH PLASTER OF PARIS BLOCKS

Approximately 4,500 plaster of Paris blocks were fabricated for use in experimental irrigation control layouts on the plantations. They are being used successfully to define depths of wetting, rate of removal, irrigation interval control in Grade A experiments, irrigation control in different soil types on a field scale, and the location of dry spots.

Thousands of acres are now under irrigation control with the plaster of Paris blocks. Kekaha Sugar Company is the first plantation to expand their installations to cover the entire plantation. Other installations of wide-spread acreages are at Grove Farm, Kohala Sugar Company, Pioneer Mill Company, and Waialua Agricultural Company. Smaller scale installations are operating satisfactorily at Ewa Plantation Company, Oahu Sugar Company, Wailuku Sugar Company and The Lihue Plantation Company.

NYLON BLOCKS UNDER INTENSIVE SCREENING PROGRAM

Approximately 550 nylon-type stainless steel units were manufactured and distributed for evaluation and testing to plantations using electrical resistance equipment. These units and others purchased on the Mainland are being tested in the field.

The largest installations are at H. C. & S. There has been some difficulty in getting the resistances to return to their original calibrated reading after irrigations. Research will continue, since the nylon blocks are sensitive in the wet range of the soil moisture curve and since they can define irrigation needs in soils that lose their available water at low tensions.

MOISTURE SORPTION EQUIPMENT ENLARGED

Equipment designed and built to define the moisture holding characteristics of soils has been in continuous operation for the past year.

Curves plotted from field capacity to wilting point show the amounts of available water present and the rate of release at the different tensions.

Moisture sorption curves were run on the principal types of soil from eight irrigated plantations. Facilities have been expanded and larger numbers of soils can be characterized in the future.

PERMEABILITY STUDIES USED TO EVALUATE SEED BED PREPARATION

Water permeability rates were used in investigations of the Storey Plow tillage to determine the effect of the additional fine material produced by the use of this plow in seed bed preparation. No significant differences either in permeability rates or in consolidation of the soil were observed during nine months of observations in soils of the Honouliuli, Manana, and Wahiawa families.

SURVEY SHOWS MECHANICAL HARVESTING PLAYED IMPORTANT ROLE

In a survey of the yield decline on the Hilo Coast, hundreds of pits were dug in fields that had been mechanically harvested one, two, three, or more times. In areas mechanically harvested three or more times, yield decline approached critical levels. Puddling and compaction of the soil (Figure 13) had resulted in anaerobic conditions in the root zone and had restricted root systems. Under these adverse conditions, yields of cane and sugar declined.

STUDIES INITIATED TO CHECK COMPACTION FROM HEAVY EQUIPMENT

Soil compaction measurements to evaluate the damage to soil tilth are being made in the field following operations of different types of heavy equipment at different soil-moisture levels.

Preliminary studies of infield tournahauler roads indicate that appreciable damage is incurred by repeated passes. Even with the additional seed bed preparations required for these infield roads, only a partial return to the former state of tilth is obtainable.

Studies of root penetration in soils compacted to varying degrees show conclusively that restricted root systems result from compaction by heavy equipment. Figure 14 shows roots failing to penetrate a compacted Low Humic Latosol of the Lahaina family from H. C. & S.

Figure 13. Puddling and compaction resulting from operating Athey wagons in wet weather on the Hilo Coast.

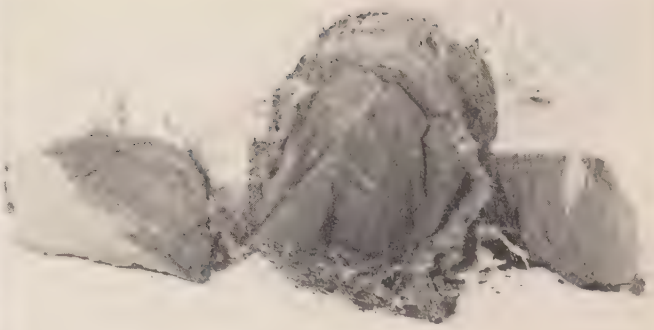


Figure 14. Restricted root systems in compacted soil shown with examples of Low Humic Latosol (Lahaina family) from H. C. & S.

INFIELD TRANSPORT CAUSING LITTLE DAMAGE

Extensive tests were conducted at Hilo Sugar Plantation Company to determine the extent of soil compaction caused by the operation of the HSPA infield transport unit. No appreciable damage was shown on bare soil areas until four passes had been made. On trash covered areas, more than eight passes were made before appreciable damage was evident.

AGE OF HARVEST TESTS HELPFUL IN PLANTING AND HARVEST SCHEDULES

Ewa Plantation Company, in harvesting the first ratoon of its test studying optimum ages of harvest, found that maximum TSAM was obtained for the 15-month harvest. Rates of sugar production fell markedly in the later harvests, supporting previous observations that ratoons close in faster, reach maturity earlier, and die sooner, than plant cane. Crop census studies revealed that for the 24- and 27-month harvests, one out of every four primary stalks was dead.

The 21-month harvest of plant cane started in May, and the 15-month harvest of ratoon cane gave an outstanding yield of 25.2 TSA for the three year period.

Data from the various Age of Harvest tests show very forcefully that the different months have widely different capabilities in the growing of cane and in the production of sugar. Cultural practices are being geared to an optimum production where a high percentage of the crop can be harvested prior to the marked drop in TSAM values.

DIFFERENTIAL THERMAL EQUIPMENT BUILT FOR CLAY STUDIES

Differential thermal equipment was built to assist in the characterization of the clays in the principal types of Hawaiian soils.

The thermal curves are being used to explain the chemical and physical behavior of many of our soils.

CONTROL TESTS AID IN CONSTRUCTION OF EARTH-FILLED DAMS AT H. C. & S.

Mechanical analyses were used in selecting material for fill in the construction of earth-filled dams at H. C. & S. Optimum compaction curves were computed for the selected material so that moisture could be rigidly controlled at the time of compaction in order to insure maximum stability.

FERTILIZER PURCHASES SHOW MARKED FLUCTUATIONS

A study of fertilizer consumption made cooperatively by the Department of Agronomy and Pacific Chemical and Fertilizer Company is reported graphically in Figure 15.

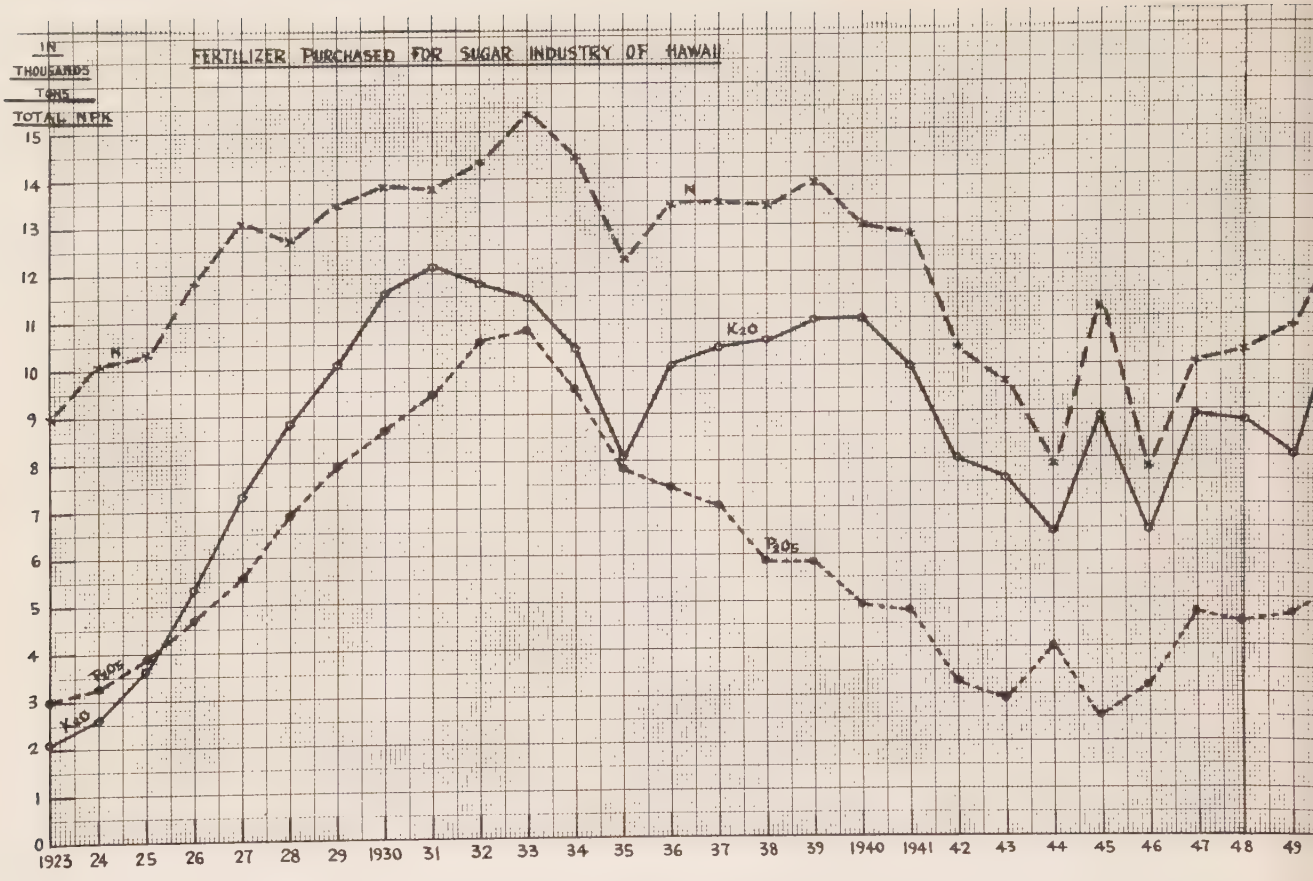


Figure 15. Fertilizer purchased for sugar industry of Hawaii.

ROOT TEMPERATURE PLAYS MAJOR ROLE IN SUGAR CANE NUTRITION AND GROWTH

Striking effects of temperature on sugar cane have been reported in the past two years by the Department of Physiology and Biochemistry. One shortcoming of the experimental controlled climate setup was due to the inclusion of the culture jars in the air surrounding the tops of the plants. This brought about a large daily fluctuation in root temperatures, which is unphysiological. Changes in the cooling system were made so that the roots are now held at fixed temperatures while the tops are exposed to air temperature which is maintained by differential thermostats at 9° F above or below the Makiki temperature.

A preliminary experiment with young plants has been recently harvested. These plants were about three months old when transplanted into the controlled climates.

Figures 16 and 17 illustrate the striking effects of root temperature seen after eight weeks.

Studies on nitrogen uptake, leaf punch analyses, and final harvest values lead to the following conclusions about sugar cane of this age:

(1) Nitrogen uptake and growth are controlled primarily by root temperature and are almost independent of air temperature.

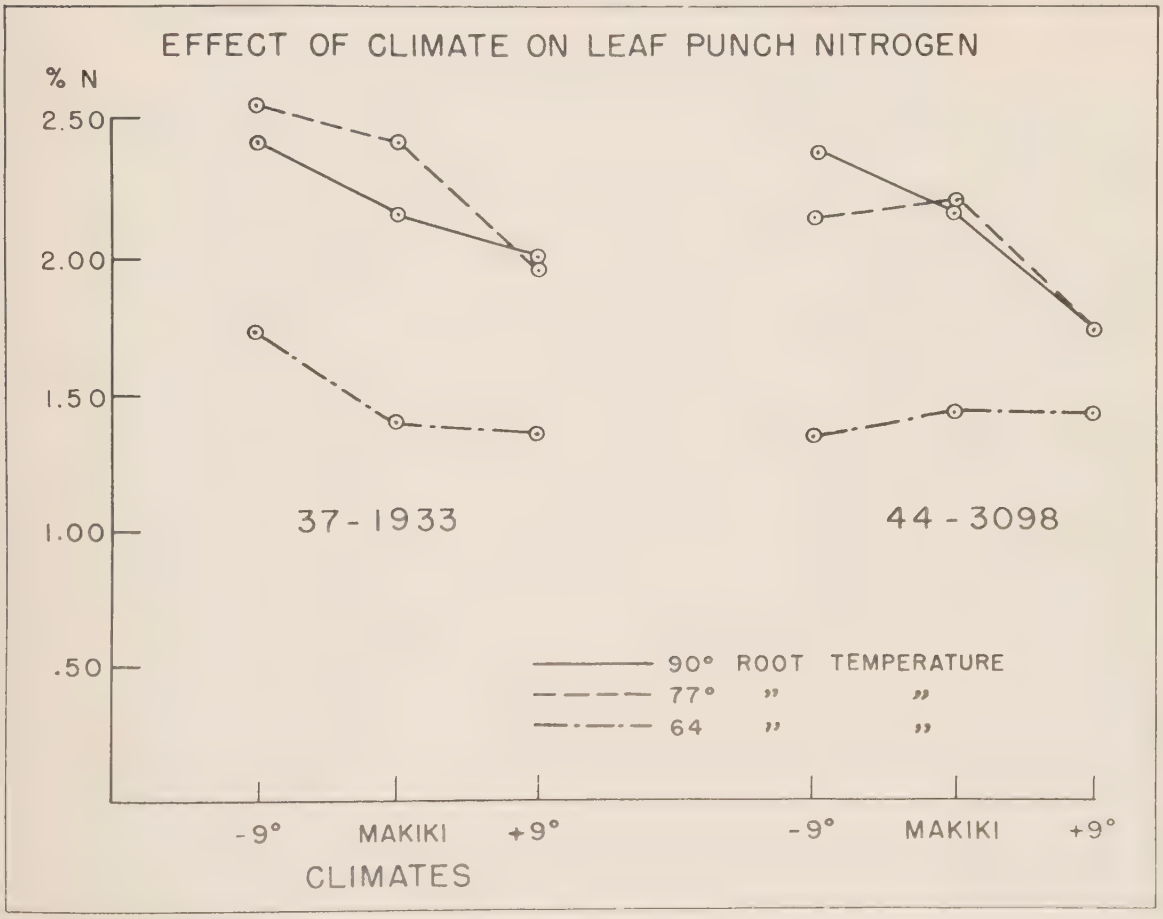
(2) Varieties 37–1933 and 44–3098 do not survive continuous root temperatures of 51°F.

Low root temperatures may largely determine leaf punch nitrogen. (Figure 18)

Figure 16. Plants are shown after eight weeks in Makiki air temperature. The roots had been held at 51°, 64°, 77°, and 90°F, reading from left to right.

Figure 17. Here are shown the roots of the plants in Figure 16.

Figure 18. Both air and soil temperatures affect leaf punch nitrogen. When the root temperature is as low as 64°F, it becomes the major climatic factor.



DISEASES

DISEASE TRIALS MOVED TO FIJI

The "Six Year Plan," set up in 1951 as a cooperative arrangement by the Colonial Sugar Refining Co., Ltd., and the HSPA to establish a testing program in Fiji to determine the resistance of Hawaiian cane varieties against downy mildew and Fiji disease, proposed that 100 varieties be sent to Fiji for testing the first year and 25 varieties each succeeding year for five years.

In accordance with this agreement, 100 Hawaiian varieties were shipped to Fiji in 1951, and were planted in a quarantine area at Yaqara. The 25 varieties for the second year of testing are to be sent in October, 1952.

In December, when the 12-month quarantine period expires, the first year's varieties will be planted in replicated plots where there will be opportunity to determine their resistance to the two diseases.

Since all further testing of Hawaiian varieties will be carried out in Fiji, the Samoan substation which was started in 1946 was officially closed on February 1, 1952.

MARTIN STUDIES SUGAR CANE DISEASES ON PERUVIAN TRIP

At the invitation of the Peruvian sugar industry and of W. R. Grace & Co., Dr. E. V. Abbott, Principal Pathologist of the U. S. Department of Agriculture at Houma, Louisiana, and J. P. Martin, Principal Pathologist of the Experiment Station, HSPA, made a survey of cane diseases in Peru, with special reference to a new disease, now known as Sclerospora disease.

Sclerospora disease causes a leaf mottling, a severe stunting of the plants (Figures 19 and 20) and excessive tillering. Affected plants produce little or no millable cane. Stem galls develop on diseased plants, usually at or near the ground level. The disease is caused by a fungus and is transmitted by diseased cuttings and by spores of the causal organism. The disease can be best controlled by selecting healthy plant material, roguing and destroying diseased plants by burning, substituting resistant varieties, and maintaining optimum drainage conditions.

Sclerospora disease is known to occur to a limited extent in Australia and Louisiana. The variety POJ 2878, which is planted on 90 per cent of the acreage in Peru, was found to be more resistant than 37–1933 and 32–8560, the latter being more susceptible than 37–1933 in all instances.

Losses from sugar cane diseases in Peru have been minor. The spread of Sclerospora disease has been limited and has caused no serious losses. Other diseases noted in Peru were mottle stripe, eye spot, cluster stool, ratoon chlorosis, sooty mold, *Cytospora sacchari*, red rot of leaf sheath, and mosaic.

Mosaic and chlorotic streak were found to be common at the sugar cane breeding station at Palmira, Colombia, as well as on Hacienda Manuelita nearby. A number of excellent canes have been developed by crossing noble and wild canes. The severity of eye spot on a few seedlings showed that the disease could be extremely serious if susceptible commercial varieties were grown.

The majority of the commercial varieties in Florida and Louisiana exhibited a high degree of resistance to Pythium root rot, mosaic, red rot, and eye spot. Disease resistance factors are of major importance in the breeding and testing program. The large variety collection maintained at the Canal Point Field Station was found to be in excellent condition and exceptionally free from disease.

Figure 19. POJ 2878, 6½ months old, is shown at Hacienda Cartavio, in Peru. The cane in front is affected with Sclerospora disease. Note the severe stunting in the first two rows in contrast with the healthy cane in the background.

Figure 20. A stool of 32-8560 affected with Sclerospora disease is markedly different in growth from the healthy cane in the background at Hacienda Cartavio, Peru.

QUARANTINE INSPECTIONS REVEAL NO NEW DISEASES

Periodic inspections of imported canes under greenhouse and field quarantine on Molokai revealed no symptoms of any foreign disease. In the field, mosaic disease was noted on NG 18 and 19 (*S. Robustum*) and on 41 MW 520 x 46 MQ 1494, both grown from imported seed (fuzz). Mosaic disease is not transmitted with true seed. During the year, the Quarantine Committee released 21 varieties, among them Trojan, and planted under greenhouse quarantine 28 varieties imported from Washington, D. C.

During plantation inspections, the commercial varieties were found exceptionally free from symptoms of disease, and no new disease was found. Mosaic disease was observed on 45–2708 in one locality of the Hamakua District. This is the first record of mosaic on a commercial variety for many years. Eye spot and brown stripe were of no economic importance. A small amount of leaf scald was found on the susceptible varieties 28–4291 and Yellow Caledonia, and a few cases were studied on 44–3098 and 32–8560, both varieties known to be resistant. However, when cane is exposed to conditions of severe drought, even the most resistant varieties may be affected with leaf scald. Chlorotic streak was causing some losses in the wet and poorly drained areas on Hawaii, but the disease was of little or no importance on the other islands. Leaf freckle was moderate to severe on canes growing under mauka conditions on Hawaii and Kauai.

GROWTH FAILURE OF 47–4991 AT WAIPIO

Cuttings of the variety 47–4991 from healthy plants and from severely stunted plants taken from a growth failure area at Waipio were treated with phenyl mercuric acetate (PMA) and hot-PMA (HPMA) and planted in the field at Waipio and at the Pathology Plot. At Waipio, the cane from cuttings from the stunted plants showed growth failure symptoms several months after planting. However, at the Pathology Plot there were no observable differences in cane growth from the different treatments. The cause for the poor growth of this variety at Waipio has not been determined.

As reported last year, the presence of leaf freckle is correlated with subnormal soil fertility. Field tests, all using the variety 44–3098, have

been designed and installed to improve soil fertility in areas where the disease is a problem. The various treatments of the soil before planting include the addition of Krilium, organic matter, bagasse, mud press, superphosphate, calcium and A-Z mixture alone and in combinations, and DD-mixture. The treatments of the growing plants include foliar applications of various chemicals. In nutrient studies, cane deficient in magnesium and, to a lesser extent, in calcium and potassium, shows a leaf spotting similar to leaf freckle; therefore, these elements will be included in foliar treatments. The incidence of leaf freckle will also be studied on cane grown in cambered beds to which N, P, K, A-Z mixture and calcium have been added.

The studies on this project are being conducted in cooperation with the plantations, the Island Representatives, and the Departments of Pathology and of Agronomy.

INADEQUATE WATER FAVORS STEM GALLS

In October, 1951, the variety 44–3098 was inspected for the presence of stem galls in 14 fields on the Maui plantations. Stem galls were found in all fields where water was a limiting factor for normal cane growth.

In an experiment at the Pathology Plot, stem galls (Figure 21) developed on internodes of the variety 44–3098 when water was withheld to the point where growth was retarded (Figure 22). Galls were not formed on stalks of cane receiving adequate soil moisture. These studies indicate the presence of stem galls on this variety to be associated with poor growth resulting from inadequate soil moisture.

Entomologists found pink mealybugs, *Trionymus sacchari*, on the stalks in all treatments, whether or not galls were produced. Stalk mites,

Figure 21. When growth was retarded by withholding irrigation water, 44-3098 developed stem galls on the internodes.

Figure 22. In testing the relation of stem galls to limited irrigation, stalks A, B, C, and D of the variety 44-3098, were grown in plots which were irrigated at 4, 7, 14 and 30 (or more) day intervals, respectively. Stalks A and B were entirely free from galls. The incidence of galls on stalks C and D was 25 to 40 per cent and 75 to 80 per cent respectively.

Tarsonemus spinipes, were not found on any of the stalks with stem galls.

The stem galls on 44–3098 are generally a flat, winged type of growth. Spiral elements of xylem tissue were found in most of the galls examined. Other types of cells and tissues observed included: epidermal leaf tissue composed of elongated and short cells, with some stomata; trichomes and serrations as found on leaves; and hairs as found on the leaf sheath. Many of the cells were thin-walled and irregular in shape. Meristematic tissue was also present in many galls.

ELECTRON MICROSCOPE USED IN MOSAIC STUDIES

In cooperation with Dr. H. Gold, Associate Pathologist of the University of California, attempts were undertaken to determine the size and shape of the sugar cane mosaic virus molecule. Juice samples expressed from healthy and diseased plants in Honolulu were frozen and shipped by air to Dr. Gold. After high speed centrifugation and other treatments of the juice samples, the purified preparations were examined under the electron microscope. No virus particles were observed in these first investigations. Arrangements were made with Dr. Gold to continue these studies. Information regarding the chemical and physical properties of the sugar cane virus may have a bearing on its transmission and field control.

Attempts at the Pathology Plot to transmit mosaic disease mechanically from Lahaina cane to other varieties have not been successful. Other techniques for transmitting the disease will be tested.

CONTROLLING PYTHIUM ROOT ROT IN SEEDLING FLATS

Of 36 fungicides tested against Pythium root rot of sugar cane seedlings in flats, only copper-8-hydroxy-quinolate gave better control of the fungus than the standard fungicide, Phygon, when used at the same dilution. Because of the present high cost of copper-8-hydroxy-quinolate, further tests with new fungicides will be made when sugar cane seed (fuzz) is again available for germination.

Actinomyces were again isolated from soils and tested against the Pythium organism for their antibiotic activity. While several of these organisms were very effective in inhibiting the growth of Pythium on agar plates, they were not effective when used to inoculate soils in which cane seedlings were grown. Since certain plant pathogens may be controlled by organisms antagonistic to them, studies along antibiotic lines are being continued.

DATA ON RESISTANCE OF CANE VARIETIES TO DISEASES BEING COMPILED

Information relative to the resistance and tolerance of sugar cane varieties to the major diseases of the world has been compiled for the use of the sugar industry.

This information is extremely valuable when varieties are to be imported into the Territory. Sugar cane pathologists in other parts of the world are cooperating on this project.

CMU AND CMUCADE TESTED FOR EFFECTS ON SOILS

A number of tests were run to determine the effects of CMU and CMUCADE on nitrate formation and on the number of soil microorganisms in Waipio Field E soil. Results indicate that CMU, even at rates as high as 64 and 128 pounds per acre foot, did not retard nitrate formation nor cause any marked effects on the total number of soil microorganisms. CMUCADE was found to retard nitrate formation with increasing effect at rates between and including 200 and 1600 gallons per acre foot. At the highest rate used, 1600 gallons per acre foot, there was a temporary, many-fold increase in the total numbers of soil microorganisms.

It was found that the behavior of CMUCADE towards nitrate formation and soil microorganisms was due primarily to the CADE fraction. Concentrated Diesel Emulsion without the activator, sodium pentachlorophenate, was found to behave somewhat as CADE had done, although the activator may have contributed to the slightly smaller amount of nitrate nitrogen in the CADE treated soil. The amounts of activator present in 800 gal-

lons and 1600 gallons of straight CADE, 53.36 and 106.72 pounds activator, respectively, definitely retarded nitrate formation during the 0- to 2- and 0- to 4-week intervals, respectively. The total number of soil microorganisms did not seem to be appreciably affected by the activator.

It was demonstrated that very high rates of CADE or its components must be applied to a soil before any detrimental effects on nitrate formation become evident.

CMU at rates even as high as 128 pounds per acre foot did not seem to affect the nitrifying organisms.

The rates of which CADE and CMUCADE were used with noticeable effects on nitrate formation are far in excess of the rates used in the field.

WILL SOIL FUMIGATION INCREASE GERMINATION AND CANE GROWTH?

Pre-plant treatment of plots with DD-mixture (Dichloropropane-Dichloropropylene mixture) at the rates of 400 and 600 pounds per acre were made at Waipio in March and May, 1952, for the purpose of studying the effect of soil fumigation on the germination and growth of H 109, 32–8560 and 37–1933, and on soil organisms. The variety 37–1933 in the treated plots has shown a better color and growth than in the check plots; no growth differences were apparent in the treated and untreated plots with 32–8560. The variety H 109 in the treated plots has shown better germination and growth than the untreated plots. It is too early to draw any conclusions regarding the final effects of these treatments on cane growth.

Laboratory studies now under way indicate that DD-mixture applied at the rates of 200, 400 and 800 pounds per acre foot definitely retards nitrate formation; DD-mixture at these rates seems to inhibit the oxidation of the added ammonium sulphate to nitrate nitrogen by the nitrifying organisms. At the rate of 800 pounds per acre foot, the total number of bacteria and actinomycetes seem to have increased, while at the rates of 400 pounds and 800 pounds per acre foot the numbers of fungi in the soil definitely decreased.

In pot studies, DD-mixture applied to the soil at the rate of 400 pounds per acre foot definitely caused a stimulation in the germination and early growth of H 109. The plants in DD treated pots appeared larger, greener and healthier. These differences became less noticeable after three months, and at four months there was little difference in size and appearance of plants in the treated and untreated pots. Plate counts of total numbers of soil microorganisms made at monthly intervals failed to show any appreciable differences between treated and untreated soils.

EXPERIMENT STATISTICS

FACTORIAL DESIGNS MORE ECONOMICAL THAN SINGLE FACTOR LAYOUTS

Although some increase has been noted in the use of the factorial designs for Grade A field tests, only about half of the newly installed experiments this year have made use of these more efficient plans. Where the basic principles of these factorial designs are clearly understood, their advantage over the single-factor design results in increased economic as well as scientific values which will continue to make them preferable in field testing.

Special interest has been evidenced in plans for determining Treatment by Location (or Field) interactions, and results from such tests are bound to increase the usefulness of the experimental results.

Interpretations from such tests will require careful rationalization of measured differences, and this will depend largely on the ability to characterize the differences in growth factors at the different locations.

Cooperative participation by two or more plantations in testing the same objective with the same experimental plan, has increased the number of Group tests. The following tests are now under way in the 1953 and 1954 crops:

Group Test No.	Objective	Participating Plantations
4	Amts x Forms of P	Hakalau, Pepeekeo, Hamakua
5	Amts P and CaO	Hakalau, Pepeekeo, Onomea, Olaa, Kohala
9	Irrigation (Soil moisture measurement)	Lihue, Pioneer, Kekaha, Oahu Sugar
10	Forms x Time of N (Uremite)	Lihue, Kilauea, Pepeekeo, Hilo, Hakalau, Olaa
11	Age of harvest x Amts N x K	Lihue, Grove Farm, Kekaha, Oahu Sugar, Olaa, Pioneer
13	Amts x Time of K	Olaa, Hilo, Pepeekeo, Hakalau, Onomea
14	Amts x Forms of P	Hilo, Pepeekeo, Onomea, Olaa, Hakalau, Laupahoehoe

STATISTICAL ANALYSES OF RESEARCH RESULTS COVER MANY SUBJECTS

Statistical analyses of harvest results have been made for the Department of Agronomy and the Department of Genetics on more than 100 of their cooperative Grade A experiments.

Statistical planning service, given before installation for most of the new plans, should insure more valid statistical interpretations of the results.

Studies with similar objectives, made on the combined results from successive crops and also on combined results from different tests or locations, have shown some real effects of treatments, independent of locations, which the individual harvests had failed to identify as being significant. More studies of this nature will increase the scope and dependability of the experimental results.

Statistical analyses for miscellaneous studies which had been made were also requested and furnished to many staff and plantation members. Thus sound guidance for interpretation of their results was provided. There is still room for use of these services in statistical planning *before* these specific projects are actually started in order to insure getting maximum information from such studies.

SAMPLING STUDIES POINT WAY TO IMPROVE CROP LOG RESULTS

With the cooperation of Lihue and Oahu Sugar, a series of sampling studies was undertaken to find the extent of the expected variation in crop log sampling, and to determine what degree of precision was possible for differences in measurements between separate 5-stalk samples. Some of these results are given graphically in Figure 23. They confirm quite similar results secured for nitrogen,

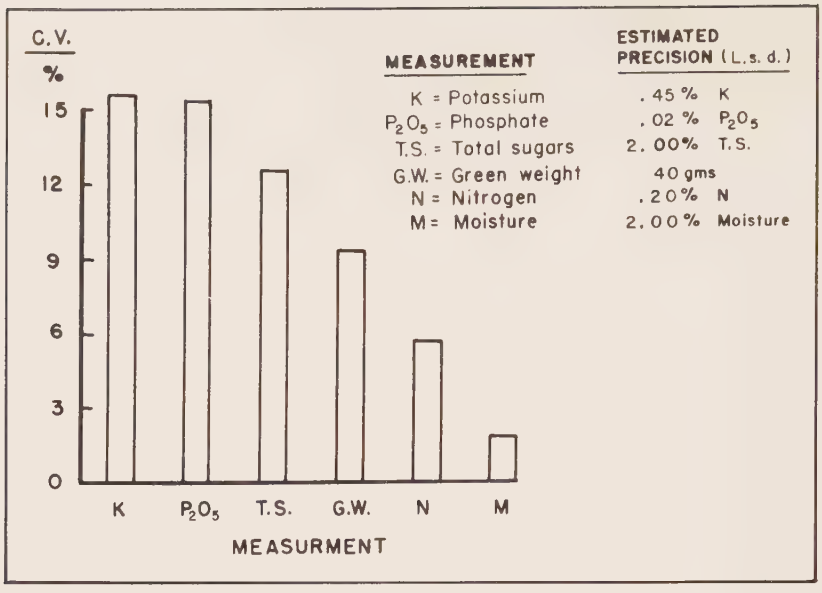


Figure 23. Average variation in standard crop log samples.

total sugars, and moisture, in previous studies (Waipio Expt. 108 and Makiki Expts. 20 and 22).

Other findings from these new sampling studies may be briefly mentioned as follows:

1. Individual sampling stations, although selected as representative of a field, were not generally found to be significantly different at Lihue, but were proved different in their percentage of moisture, total sugars, N, and K, at Oahu Sugar.

Where such significant station-to-station variation exists (Figure 24), stalks for the crop log sample must be taken from several, scattered parts of the field, rather than from a single station. The most economical procedure for sampling the field can be worked out by making a statistical estimate of the number of stations and number of stalks per station needed in order to measure a specific difference with the desired degree of confidence. For example: in Oahu Sugar's Field 50, in order to measure a difference of 1.0 per cent in total sugars between two samples with 95 per cent confidence, the estimate for equivalent accuracy would be either (a) 6 stalks from each of 5 stations, hence a total of 30 stalks, or (b) 9 stalks from each of 4 stations, hence a total of 36 stalks, or (c) one stalk from each of 15 stations, or only 15 stalks.

2. Highly significant differences between crop log samples from different sampling stations, which had been found in per cent of total sugars on January 16, were not found at the same station six weeks later.

3. Averages from five regular 5-stalk samples taken on May 6 showed a significant difference (loss) in their percentages of moisture, N, and total sugars, from similar samples taken *on the previous day* from five comparable neighbor-stations.

4. Highly significant differences were found in the per cent of P_2O_5 in the average of 41 field crop log samples collected from the same stations by two different samplers within 30 minutes of each other. Single standard crop log samples taken by two different samplers from the same stations varied by as much as 2.8 per cent in moisture, 3.0 per cent in total sugars, 0.33 per cent in nitrogen, 0.045 per cent in P_2O_5, 0.52 per cent in potassium, and 14.6 grams in green weight.

In Figure 25, the measurements from four studies made on per cent total sugars in sheaths were pooled to show the effect of different sampling schemes on the variance for the means when there are differences between stations. From the two graphs, it is clear that when there are significant differences between stations, an increase in the number of stalks taken from any one station is not very effective in reducing the variance of the mean, whereas the effect from an increase in the number of stations brings about a considerable decrease in the per cent K variance.

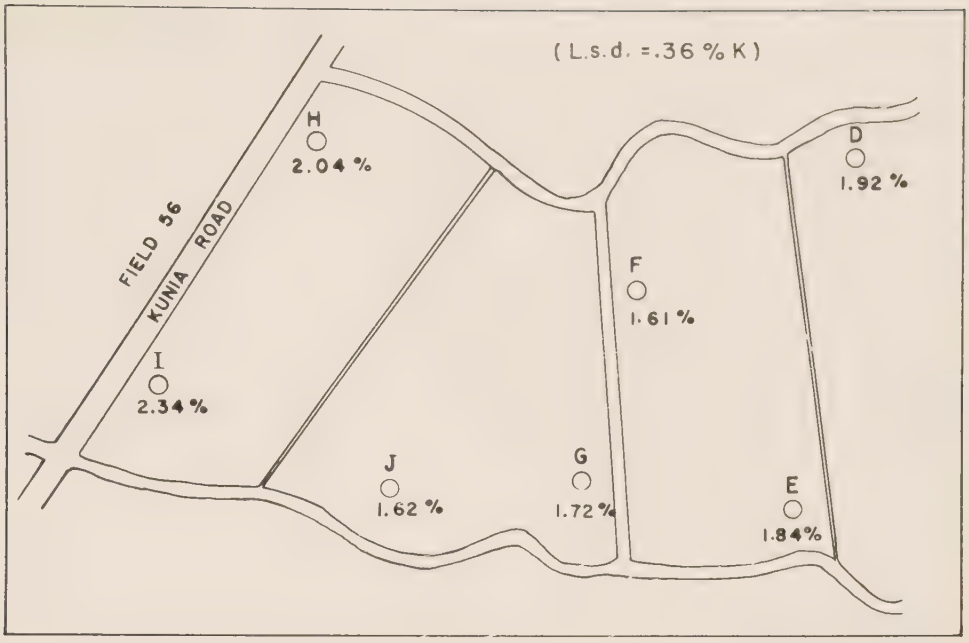
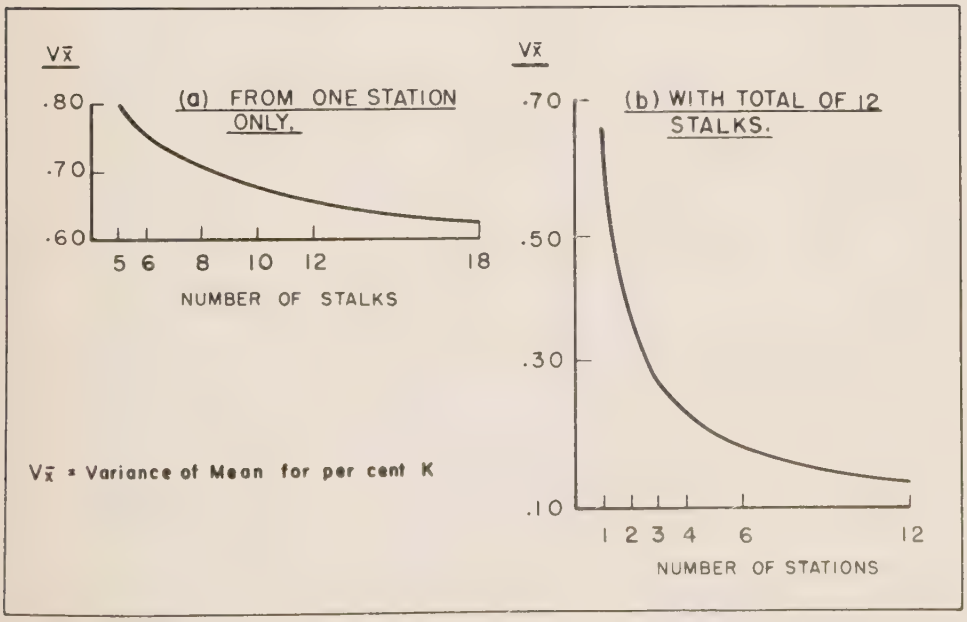


Figure 24. Variation in per cent K in leaf sheaths of five-stalk crop log samples taken from stations in Field 50, Oahu Sugar Company.

Figure 25. Effect of different sampling schemes on the variance for means when there are differences between stations. Measurements are made on per cent total sugars in sheaths.



POTASSIUM CHLORIDE CRYSTALS IN LOW-GRADE MASSECUITE AT H. C. & S.

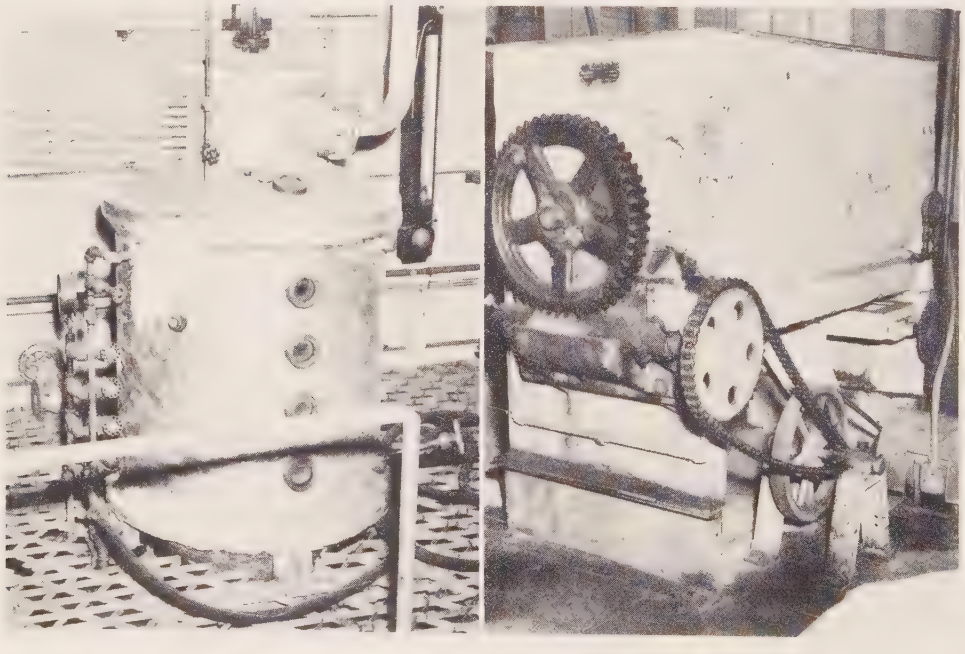
The unique problem encountered at both factories of H. C. & S. and caused by crystallization of potassium chloride in low-grade massecuites, has been serious during the 1952 season. As reported in 1951, the crystals are caused by high ash levels due principally to potassium chloride in the juice. A thorough study by the plantation staff has shown that the high ash juices come from fields irrigated with a high percentage of pump water. Juices from mauka fields irrigated with mountain water are lower in ash.

Solution of the problem lies either in reducing the soluble ash content of the juice, or in dissolving the potassium chloride crystals without dissolving sucrose. A promising method based upon the latter principle has been developed in the laboratory of the Department of Sugar Technology. Low-grade massecuite, containing the potassium chloride crystals, is treated with a molasses from the Hilo area which is saturated with respect to sucrose but unsaturated with respect to potassium chloride. Potassium chloride is dissolved without the loss of sugar.

A pilot plant vacuum pan and crystallizer have been sent to Puunene and are being used by the mill staff to develop the method. (Figure 26)

Results to date indicate that by boiling the strike in the presence of low ash molasses, in this case from Olaa, the quantity necessary to prevent salt crystals is less than 10 per cent. Commercial application of the method thus appears practicable.

Figure 26. The experimental vacuum pan (left) and crystallizer (right) are being used at H. C. & S. in the salt crystal investigation.



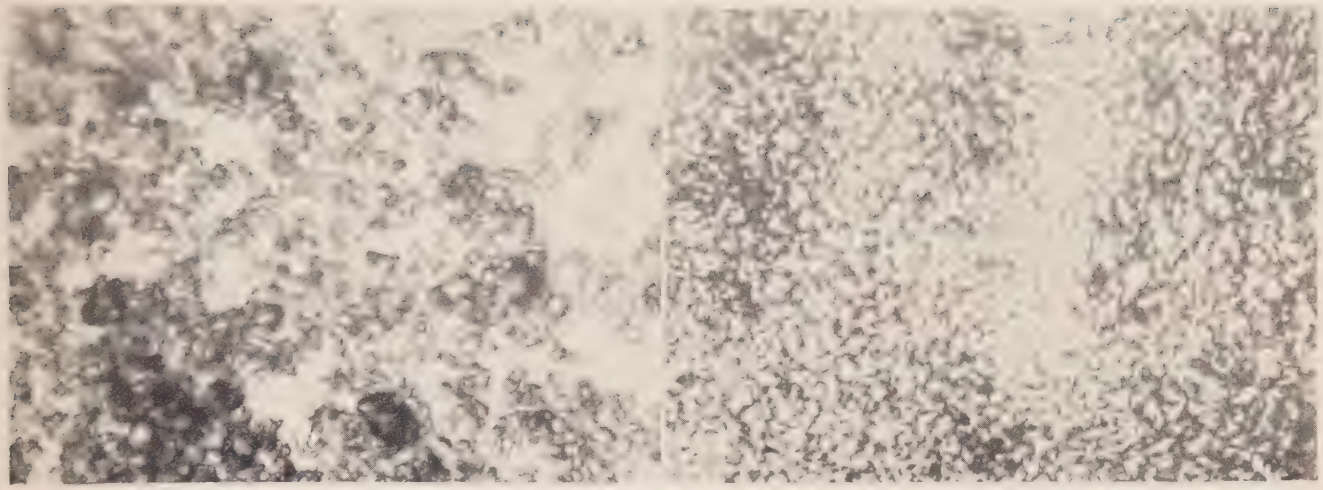


Figure 27. The fondant sugar now widely used in Hawaii for graining low-grade pans is shown at the left. The new seed slurry is shown at the right.

GUIDE TO MOLASSES EXHAUSTIBILITY

During the past two years, the Department of Sugar Technology has been carrying on investigations which are due to be completed by the end of 1952 and which have demonstrated that the HSPA Reducing Substance to Ash ratio guide, in use for many years, is more reliable than any guide used elsewhere in the sugar industry. Nevertheless, a recently developed guide, based upon reducing substances and specific conductance, is an improvement over the old both in applicability and simplicity of analysis. With the introduction of the new guide, it will be possible to eliminate the routine molasses boiling-down tests and the resulting Boiling Test Correction which is used at present.

SEED SLURRY FOR LOW-GRADE GRAINING IMPROVED

An improved seed material for graining low-grade pans has been developed. This product is made by grinding granulated sugar under isopropyl alcohol in a ball mill. The seed is finer and much more uniform than the fondant sugar which is now widely used in Hawaii (Figure 27). Measurements show that the particles number 2×10^{11} per gram of sugar.

Strikes boiled at Hutchinson Sugar Plantation Company and Hawaiian Agricultural Company indicate that the new seed gives a uniformly satisfactory grain.

PRESENT LIMING PRACTICES GIVE BEST RESULTS

The clarification procedure used in Hawaii at present involves liming the cold juice to a pH of 8.3 and subsequent heating. This procedure was developed with juices from different varieties than those now grown, and before mechanical harvesting became general.

Laboratory study has demonstrated that, in general, this procedure still remains the best to follow. It usually gives better clarity, maximum phosphate precipitation, minimum change in reducing substances, and maximum purity increase.

Liming higher than 8.3 is not recommended due to increase in calcium content and destruction of reducing sugars. If liming below 8.3 is necessary because of high volume of settlings, it is advisable to use soda ash to maintain the pH of the juice.

PHOSPHORUS PRECIPITATION DURING CLARIFICATION SHOWN BY RADIOACTIVE TRACER STUDY

Completed tests using radioactive phosphorus showed that inorganic phosphate added to juice is 99 per cent precipitated by liming to pH 8.5, but that phosphorus occurring in the cane plant is only

TABLE IV

CLARIFICATION INVESTIGATION WITH RADIOACTIVE PHOSPHORUS

Phosphorus Precipitated %

Liming pH	Phosphate Added Mixed Juice	Phosphate Fed Cane 2 Months Before		Phosphate Fed Cane* 5 Months Before	
		Fresh Cane	Sour Cane	Fresh Cane	Sour Cane
7.5	98.9	87.4	87.1	75.2	63.9
8.5	99.4	91.2	86.5	75.7	65.0

*This cane was physiologically old.

90 per cent precipitated. For physiologically old cane and for sour cane, the precipitation is considerably less. (Table IV)

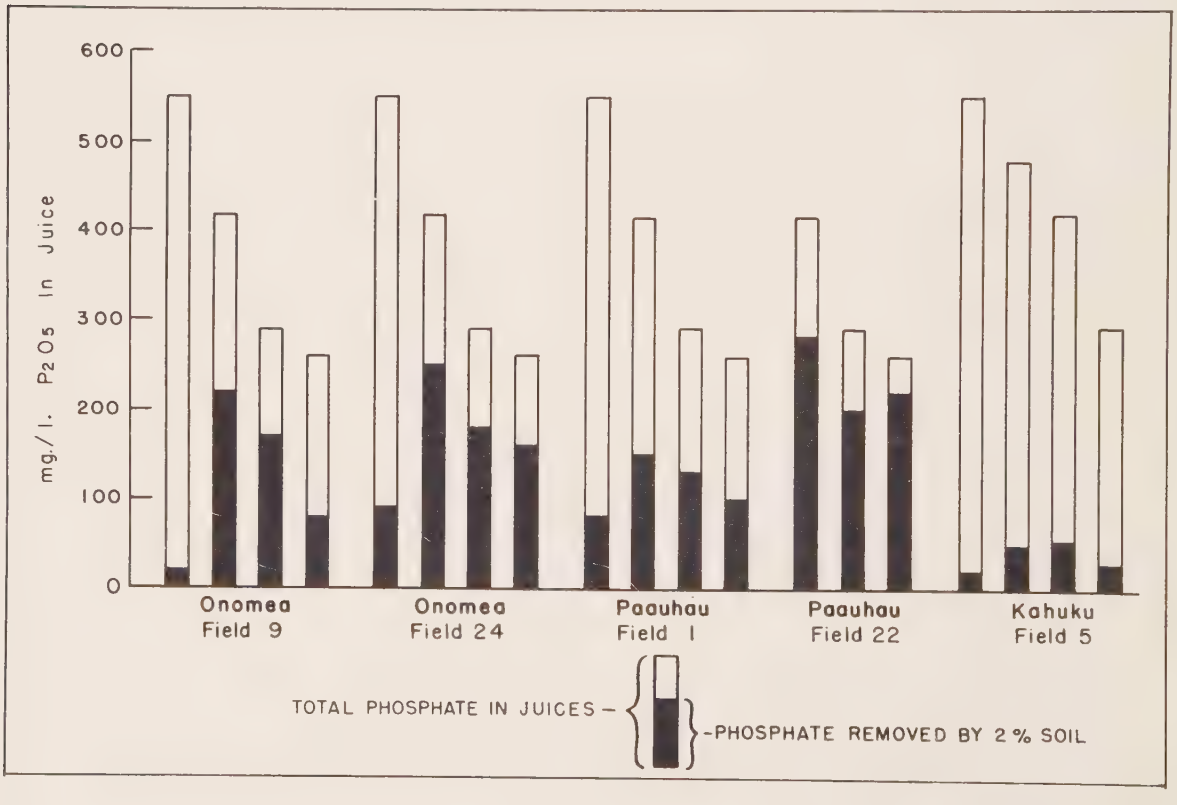
The results indicate that normally about 10 per cent of the phosphorus in juice is not in the form of ionic phosphate.

It is probable that numerous organic phosphorus compounds occur.

SOILS REMOVE PHOSPHATE FROM JUICE

Results shown in Figure 28 demonstrate that soils low in P_2O_5 will adsorb phosphate from juice, and will thus interfere with clarification effected by the precipitation of calcium phosphate.

Figure 28. Soils low in P_2O_5 remove phosphate from juice.



"SUPERSTAT" INEFFECTIVE AT KAHUKU

A "Superstat", an electrical device of English manufacture designed to inhibit hard scale formation in juice evaporators, was installed in the evaporator feed line at Kahuku Plantation Company and put in operation during alternate weeks over a two-month period.

From a study of juice composition and of the physical and chemical characteristics of the scale, it has not been possible to determine that any improvement was effected by the use of the "Superstat."

Continued laboratory tests indicate that sulfamic acid is almost as effective as muriatic in removing scale from evaporator tubes.

POL AND SUCROSE RELATIONSHIP IN HAWAIIAN RAW SUGARS

Normally, the sucrose analysis of a raw sugar gives a higher value than does simple polarization. During recent years, however, the reverse has been true for many Hawaiian raw sugars.

A carefulstudy of sugar samples taken from 20 factories during 1952 gave an average polarization 0.11 higher than sucrose. At first, it was thought that this was due to the glucose and fructose ratio, but apparently it is due to some other factor.

The problem is important because raw sugar is sold on a pol basis but refinery recovery is on a sucrose basis.

INSECTS

SUGAR CANE INSECTS AT LOW EBB IN 1952

During the past year, less damage has been done by sugar cane insects than in any previous recorded year. On all of the plantations, injury has been so slight that it would be impossible to measure it in terms of sugar lost. On some of the plantations, it is difficult to find individual living specimens of insects that were once major pests, such as the leaf hopper and the beetle borer. No armyworms have been seen. Of the minor insect pests, only the cane aphis and the leafroller need be discussed briefly. The status of the Anomala beetle remains satisfactory and unchanged.

During the hot summer months, the cane aphis, *Aphis sacchari* Zehnt., became conspicuous in several areas in the Territory. In no case, however, did it spread over more than a few acres before the ladybird *Coelophora inaequalis* eliminated the outbreaks.

As usual, the leafroller, *Omiodes accepta* Bult., was found in the uplands of all the plantations on the island of Hawaii, and was very scarce on all the other islands. For the first time in several years, leafroller damage on Hawaii appeared to be definitely declining. Beneficial insects that attack the leafroller caterpillar were found in greater quantity this year than ever before. All of these beneficial insects are species previously known in the Territory.

THREAT OF INSECT IMPORTATION BY AIR CONTINUES

Transportation by aircraft between Hawaii and other countries continues heavy, increasing the risk that new pests will reach the Islands and become established. As evidence that the danger is real, illustrations will be presented of several pests that inspectors of the U. S. Bureau of Entomology and Plant Quarantine found during the past summer on planes arriving from foreign countries in the Pacific and, in one case, on a surface vessel arriving from Midway Island.

Perhaps the most shocking case is that of a passenger plane which arrived at Honolulu airport from Fiji on May 14. There were several thousand of the Fiji sugar cane leafhopper, *Perkinsiella vitiensis* Kirk., in various parts of the plane, and several hundred of them were reported alive by the inspector. These insects had entered the plane at Nadi airport in Fiji while the craft was refueling. This was at night when the leaf hopper normally flies. This insect does not occur in Hawaii. It is considered the major, and probably the only, vector of Fiji disease of sugar cane in that country. The Federal plant inspectors took prompt action and the plane was thoroughly fumigated. It is possible, however, that some of the hoppers escaped with the passengers and crew. The insect, which is a little more than one-eighth of an inch long, is shown in Figure 29. It is very similar to the sugar cane leaf hopper that has been in Hawaii for many years.

On June 16, a large, dead Anomala beetle, *Anomala cuprea* (Hope), was removed from a plane arriving at Honolulu Airport from Japan. The beetle, almost an inch in length, is shown in Figure 30. A month later, another Anomala beetle, of undetermined species, was taken dead from a plane arriving at Honolulu Airport from Haneda Airport, Japan, where, Federal inspectors report, this species is common. It is about half an inch long, and is shown in Figure 31.

On June 17, an inspector removed a large living beetle, *Protaetia orientalis* (Gory & Percheron) from a plane which arrived at Hickam Field from Japan. This was another beetle of the family Scarabaeidae, whose grubs feed on underground plant material. The beetle measures nearly an inch in length, and is shown in Figure 32. Another large Scarabaeid beetle, *Anomala viridana* Kolbe, bright green in color and nearly an inch long, was taken alive from a plane arriving at Honolulu Airport from Wake Island on July 2. This beetle is reported to be common on Wake Island, only a few

Figure 29. The Fiji leaf hopper is normally as long as the line.—

hours by air from Honolulu, and is illustrated in Figure 33.

Another Anomala beetle, *Anomala sulcatula* Burmeister, is now common on Midway Island. The grubs of this beetle are root-feeding pests. During June, officers of a ship stopping at Midway reported seeing many of this species, and they submitted to Federal plant inspectors a live specimen, taken on board while en route to Honolulu. This beetle is about half an inch long and is shown in Figure 34.

That some insects arrive in Hawaii on planes from outside countries, escape detection by the inspector and leave the plane before fumigation, was

Figure 30. The **Anomala cuprea** beetle is one inch long, or:

Figure 31. This beetle of the **Anomala** species is this long:

Figure 32. This beetle, **Protaetia orientalis,** is this long:

Figure 33. The **Anomala** viridana is this long:

Figure 34. The **Anomala** sulcatula is this long:

proved on August 18 when 18 planes, mostly military, came into Honolulu Airport from foreign areas. An alert Federal inspector found a large, living Anomala beetle in the Airport washroom on that date. This beetle had undoubtedly escaped from the hand baggage of one of the passengers who used the washroom after leaving one of the planes.

The information respecting the above interception of insects by plant inspectors was kindly supplied by Mr. K. L. Maehler, who is in charge of the Federal Plant Inspection service in Hawaii. There are 46 Federal inspectors in service at present. An effort is made to meet and inspect every plane and ship arriving from foreign countries. Inspectors of the Territorial Board of Agriculture & Forestry collaborate in this work, giving particular attention to planes and ships from the Mainland. Few, if any, countries of comparable size to Hawaii, have a comparable plant quarantine service.

STATION'S INSECT REFERENCE COLLECTIONS MADE MORE ACCESSIBLE

The Department of Entomology is arranging the extensive collection of Hawaiian and foreign insects, comprising some 400,000 or more specimens, in new containers that will improve their accessibility for study, will add greatly to their safety and preservation, and will display them in a very attractive manner. During the year, about 10,000 specimens belonging to this Station were returned to Honolulu from the British Museum of Natural History in London, where they have been under study by Consulting Entomologist, R. C. L. Perkins, for many years.

The reference collections constitute invaluable sources of information to the HSPA entomologists whenever it may become necessary to find beneficial insects to control new sugar cane insect pests that may invade the Territory in the future.

MECHANIZATION

The major work of the Department of Agricultural Engineering during the past year has continued to be the development of sugar cane machinery for cutting, for infield transport, and for cleaning, with the aim of reducing harvesting losses and over-all costs, and of improving ratoons. By combining principles and mechanisms, the development of cutters over the past several years has progressed from single- to multiple-operation machines, based on the conclusion that the end result would be a machine in the harvester class, performing all harvesting functions and delivering the cane into a transport unit.

During the past year, in addition to the program in progress, renewed consideration was given to the single-operation type of machine. There is urgent need for immediate improvement in ground cutting, and there is also the possibility of attaining much greater simplicity and flexibility.

A single-row cutter for irrigated cane has been designed, built, and demonstrated.

The side-bar cutter for unirrigated cane was improved and amended by the addition of a push rake, making a flexible machine with current possibilities.

As a cooperative project with the plantation, the Kekaha Harvester was designed for Kekaha.

Experimental changes as a means of obtaining data for further developments have been made on the Station's direct-mounted cutter for unirrigated cane.

Interested plantations have cooperated in further development of the side-mounted cutter-windrower type of machine.

A cane salvage installation, based on one phase of the development of dry cleaning cane, has been made at Kohala.

A portable dry cleaning machine is being built to permit further study of the possibilities of separating leaf trash from cane stalks in the harvest field.

A self-propelled track-type cane transport has completely changed the infield transportation of cane under wet conditions.

INFIELD TRANSPORT UNIT PROVES VERY SUCCESSFUL ON HILO COAST

The infield transport of the self-propelled track-type shown in Figure 35 has provided a solution for the problem of moving cut sugar cane from within the field to the side of road or flume. The experimental machine built by the Department of Agricultural Engineering has transported 57,700 tons on seven plantations on Hawaii since its initial operation at Hilo Sugar on September 21, 1951. An average optimum performance has been 52 tons per hour with a 600-foot round trip haul. The unloaded weight of 14¾ tons, plus the rated load of eight tons, gives an average ground pressure of 5.36 pounds per square inch. The 108-inch track gauge makes it possible to straddle rows and to avoid traveling on cane stools. Turns of 180 degrees are unnecessary because the machine can travel in both directions with four travel speeds ranging from 1.5 to 3.4 m.p.h. Several innovations included in the design facilitated the construction of a wide-gauge machine. The steering clutch assembly for each track is housed within the track assembly, which is, in turn, attached to the chassis frame with provision made for track oscillation. The chassis frame itself is stabilized by a center pivot and a bell crank tie-rod assembly placed at each end of the frame.

CUTTER-ONLY FOR IRRIGATED CANE MAKES DEBUT

Described as a "cutter-only", the irrigated cane cutter shown in Figure 36 has been developed to cut one line of cane growing in a furrow with a minimum number of mechanisms and parts. The 60-inch gauge, 75 h.p. prime mover travels on the ridges on each side of the line being cut. There is a narrow paddle wheel on each side of the ground knife housing which lifts the cane high enough to be picked up by the rotary vertical knife which is located over the center of the ground knife. The vertical knife splits the line of cane so that the machine moves down the center. A lug-

Figure 35. At the left, the infield transport unit, built especially for use in wet areas, is shown fully loaded, and at the right in the process of side-dumping the cane. The unit can travel in both directions and is built to straddle the cane rows.

linked conveyor chain on each side of the nose of the machine keeps the cane moving. The halves of cut cane, instead of falling outward or into the uncut cane, are held upright as the machine goes through, falling partially back into the line as the machine passes.

In cutting irrigated cane, close following of the furrow is important in order not to use most of the power in reshaping the line with the rotary ground knife. In an effort to solve this problem, the cutting-dividing assembly, built on the front end of side frames which are pushed from the rear of the tractor, is free to shift independently of the prime mover within defined limits, and the prime mover needs only to follow its lead. This feature has been partially successful but, because side pressures shift and vary during the cutting process, more development is necessary.

Continuous field operation is now determining the production rate as well as the quality of work done. The machine weighs 18 tons with a ground pressure of 31 pounds per square inch. The cutting-dividing assembly is driven by a 120 h.p. auxiliary engine. Quality cutting in the direction of the lay or recumbency of cane has always been difficult, but good cutting under this condition is made possible by cutting slightly below the ground surface. Accurate cutting height control is assured by a combination of spring-loaded lift cylinders and hydraulic pressure control.

CUTTER-BAR AND PUSH RAKE COMBINATION TRIED ON BIG ISLAND

In 1948, work on the side cutter-bar machine was discontinued by the Department of Agricultural Engineering in favor of a machine combining the functions of the cutter-bar and the pickup-windrower. During 1951, Kaiwiki Sugar Company became interested in using the cutter-bar unit as a supplement to their cutter-windrower. In cooperation with Kaiwiki, the cutter-bar assembly has been sufficiently improved to make it a reasonably trouble-free machine. (Figure 35)

The need for a separate push rake to shunt the cut cane aside before the next row is cut was eliminated by adding a push rake to the cutter-bar tractor. The pattern of operation is similar to that of a push rake. The length of cut depends upon the capacity of the push rake to accumulate and push the cut cane. Length of cut and push varies from 75 to 150 feet, depending on the cane variety and conditions. Production has averaged approximately 22 net tons per hour, with a D-7 tractor as the prime mover. Best results have been attained by cutting against the recumbency pattern, with the cutter-bar on the high side of the tractor when working on a slope. At Kaiwiki, the right-handed machine fills this requirement.

Because of the results obtained at Kaiwiki, it

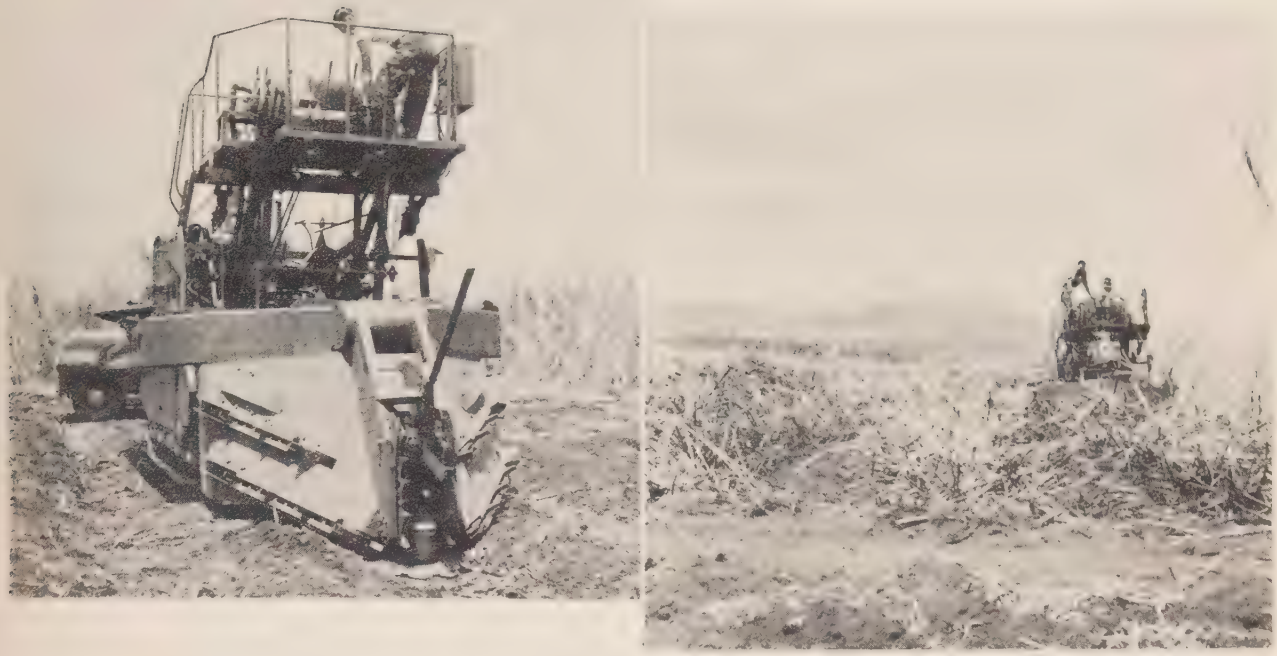


Figure 36. The cutter-only for irrigated cane is shown at the left. This machine cuts one line of cane at a time, and the type of work it does is shown at the right.

Figure 37. The cutter bar and push rake combination is shown as used at Kaiwiki and also as adapted for a smaller tractor at Onomea. The Kaiwiki unit has only one ground knife with two pickup tines, while the Onomea machine has two ground knives and no pickup tines.

Figure 38. The Kekaha direct-mounted cane harvester is shown at the left as it was first built with a secondary conveyor loading the cane into a following truck. The picture on the right shows the later adaptation made by the double-ended cross conveyor which windrows the cane across the rows.

was decided to build a second unit on a tractor one size smaller, including in the design not only the improvements made on the Kaiwiki machine, but also some of the results obtained from experiments on the direct-mounted unirrigated cutter. The unit also shown in Figure 37 was designed for a TD-14 tractor at Onomea, and length was added to both ends of the track grousers to give a track width of 28 inches. Damage to the field while turning was reduced by curling the ends of the grousers upward. The total weight of the machine is 29,800 pounds with 7.95 pounds per square inch ground pressure on the cutter-bar side, and 5.85 pounds per square inch on the other side. The two pickup tines and single ground knife were replaced by two ground knives. The rotary and trimming knife was mounted on the inside of the support plate. An overload slip clutch was incorporated in the drive to the cutter-bar.

The operation of the machine has been good, and it has been possible to cut satisfactorily across as well as with the rows. Cutting with the recumbency of the cane has been somewhat improved, though better work is still done against the lay of the cane. Part of the success of the two ground knives is due to the accurate gauging of the cutting height by the gauge wheel on the outer end of the bar and by the tractor gauge on the other end. The quality of the work has varied with conditions in the Hilo area, the best results being obtained during the drier periods.

The maximum length of cut and push has been about 110 feet, and production has ranged from 20 to 25 net tons per hour.

KEKAHA BUILDS DIRECT-MOUNTED CANE HARVESTER

The Kekaha Harvester was the result of a cooperative project, with the engineering, design, and drawings supplied by the Department of Agricultural Engineering. While the design of the cutting, pickup and conveying assemblies was based on past experience, several new ideas worthy of development were included, such as constructing the elevating conveyor in two sections with the lower hinged to the upper, placing a set of Olsen-type desoiling rolls between conveyor sections, and using one large engine to operate the entire machine. The set of three Olsen-type rolls is effective in transferring the flow of cane from the lower conveyor chains to the upper set, and in removing loose soil and trash fines without losing cane shorts.

The direct-mounted two-way machine shown in Figure 38 is built on a 62-inch gauge TD-18A tractor. Directly over the tractor is the 6-foot wide conveyor with the ground knife in the center and a side trimming knife on each side. The TD-18A engine was replaced by a UD24 of 180 h.p. Power is fed into the transmission at half speed so that the travel speeds are reduced to one-half standard, which gives a good selection of cutting speeds to

Figure 39. The cutter-loader for unirrigated cane is shown at left while being tested. At the right the two ground knives on the cutter revolve toward each other.

fit conditions without the necessity of throttling the engine. The machine weighs 25 tons with a ground pressure of 14.15 pounds per square inch.

The machine was first built and operated as a cutter-loader, with the secondary conveyor discharging the cane into a closely following truck. However, time was lost in changing trucks, and the maximum possible load was too small because of the fluffy arrangement of the cane. So, in order to step up production, Kekaha decided to replace the secondary conveyor with a double-ended cross-conveyor which would accumulate the cane on the machine and windrow it across the rows. The machine is well balanced and turns easily. The cutting and pickup have been good. Production is being determined.

CUTTER-LOADER FOR UNIRRIGATED CANE TO BE TESTED AT LAUPAHOEHOE

Described in the 1951 report as a direct-mounted, two-way cutter-windrower, this machine was a project intended to combine two requirements not filled by side-mounted equipment: it would be two-way, and the prime mover would travel in the inter-rows. The machine is shown in Figure 39.

The prime mover is a 60-inch gauge, 75 h.p. tractor, and the complete machine weighs 18¼ tons with a ground pressure of 10.3 pounds per square inch. The single ground knife, straddled by two pickup tines, was expected to cut with the recumbency of the cane, with accurate gauging of the ground cutting height. As this result was not satisfactorily attained, the machine ceased to operate as a two-way unit in many places.

Because field operation revealed major and minor basic problems which need solution, the experimental point of view will be continued and substantial changes will be made.

It was decided to try two ground knives revolving toward each other. As a possible improvement in accurate cutting height control, a spring-loaded hydraulic equalizer was put in the hydraulic lift. To simplify the design, it was decided to try mounting the slow speed rotary side trimming knife, which had proved superior in some respects to other knives, on the inside of the support plate. A trash conveyor, installed over the tractor engine, disposed of the leaf trash fed back from the elevating conveyor. It was felt that with a light and compact machine, a continuous discharge should be adopted, and so the heavy cross-conveyor was replaced by a narrower, lighter assembly which could discharge in either direction. It was designed so that its height in relation to the discharge end of the elevating conveyor could be changed. Field operation has shown progress. The arrangement of the side-trimming knives is being used on other machines. The cross-conveyor functions well, and a drop of 12 inches from the deck of the elevating conveyor to the deck of the cross-conveyor has proved satisfactory.

All experience indicates that, in order to have

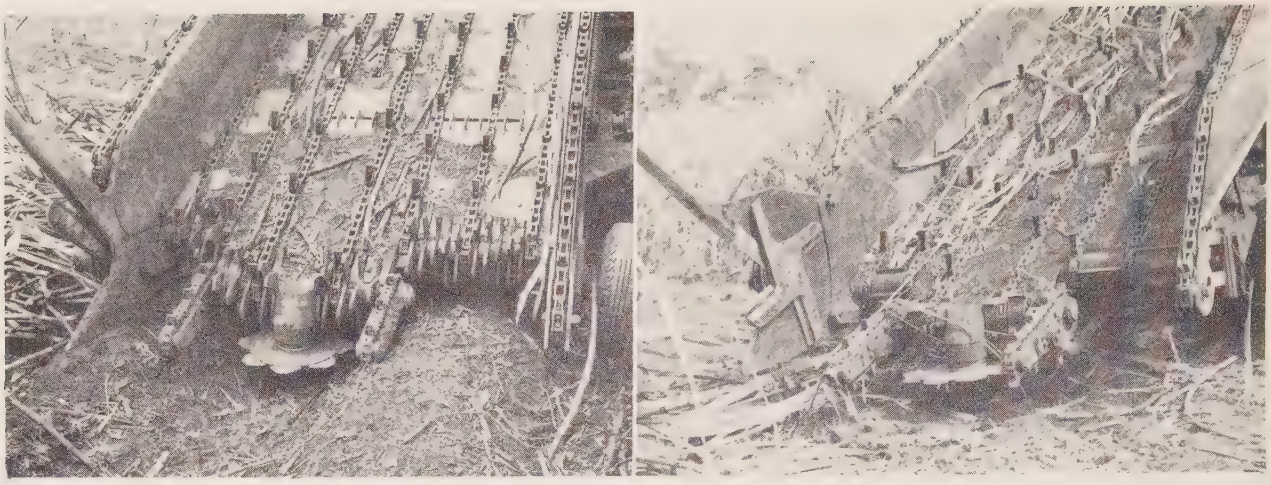


Figure 40. At left, the cutter-windrower is shown as originally built for use in cutting irrigated cane. At the right, changes have been made by Lihue to take advantage of recent developments on machines for cutting unirrigated cane. Shown are the inside rotary knife substituted for an oscillating knife, paddle drums on the pickup roll instead of prongs, and a smooth desoiling roll on the upper edge of the gap instead of a flanged roll on the lower edge of the gap.

loads of good density, the cane conveyed into a transport must be cut into relatively short lengths. Work is in progress to install two rotary knives in the elevating conveyor to cut the flow into three ribbons. Still to be tested is a topping attachment which would top some of the standing cane in the adjacent row and drop the tops into the row which has been cut.

SIDE-MOUNTED CUTTER-WINDROWER (DUNCAN CUTTER) IN PRACTICAL USE AT LIHUE

Development of the side-mounted cutter-windrower has continued cooperatively by the Department of Agricultural Engineering and the interested plantations. Recently, Lihue converted a cutting assembly so that it could be used in cutting irrigated cane. The machine, based on the original unit, incorporates the successful improvements made in machines for cutting unirrigated cane.

The practicability of this type of machine for cutting irrigated cane under the conditions prevailing at Lihue is now being determined. The cutters for both irrigated and unirrigated cane are shown in Figure 40.

CANE SALVAGER OPERATES EFFECTIVELY AT KOHALA

As reported in 1951, two principles for the separation of cane shorts from a relatively large volume of leaf trash were tested experimentally by the Department of Agricultural Engineering in cooperation with Kohala. The peg tooth drum with air blast proved to be more efficient and effective than the suction drum. Kohala made a permanent installation at their mill cleaning plant from designs and drawings furnished by the engineers. After the initial operation, the principal amendments were the addition of a paddle wheel over the trash receiving tank, the removal of one of the two combing rolls over the drum feed conveyor, and the increase from 22 to 42 inches of the drop from the hang-up roll to the return conveyor for salvaged cane. The salvager is shown in Figure 41.

This project was an outgrowth of the experimental work in progress on the dry cleaning of cane. As with the separation of leaf trash from cane, it was found essential to feed the material to the drum assembly as a thin blanket. The cane salvage efficiency ranges from 65 to 75 per cent, with an average of 70 per cent. Due to unusually adverse weather and to other setbacks, Kohala has not been able to determine accurately and statistically the economics of the salvager over an entire grinding season. Results to date indicate that the investment will yield very satisfactory returns.

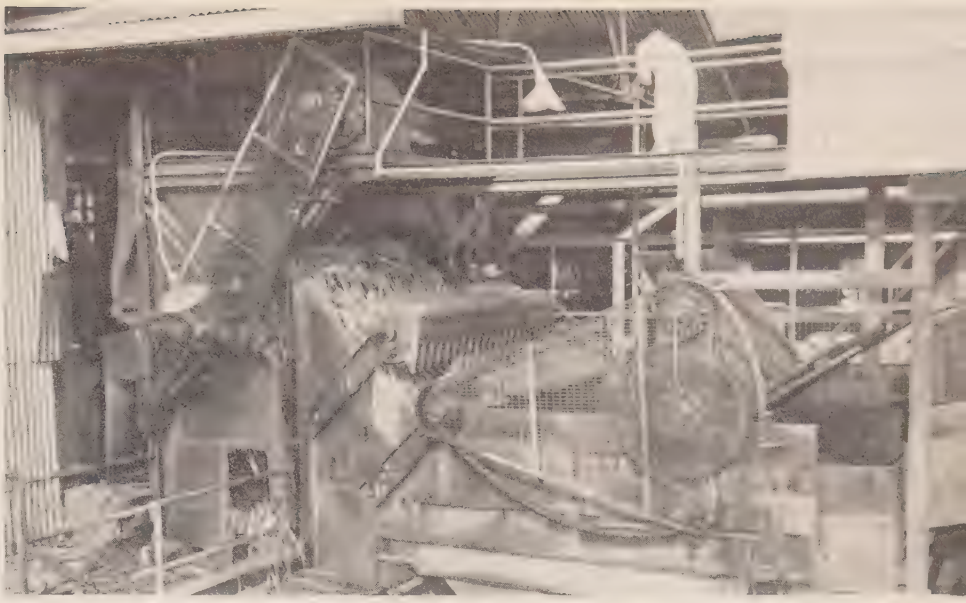


Figure 41. The cane salvager was permanently installed in the Kohala mill after experiments proved its effectiveness in separating cane shorts from trash.

PORTABLE CANE CLEANER IN PROCESS OF CONSTRUCTION

Experimental work on the separation of leaf trash, loose soil, and gravel, from field harvest cane is continuing in the Department of Agricultural Engineering.

Now being constructed is a portable unit, comprising the most recent improvements. Figure 42 shows a side elevation of the cleaner which has been designed to operate with cutter-cut cane, which is easier to handle than push-raked cane.

A slow speed feed conveyor, 9 feet wide, feeds a high speed carding elevator conveyor of the same width. Four grasshopper-type knives, located in the carding elevator, reduce the cane to an average length of 27 inches, and cut the leaf trash and tops loose from the stalks. Other types of knives can be installed at this same point if they prove necessary. The thin blanket of cane is delivered to the 9-foot long peg tooth drum and air blast which separates leaf trash and cane. The separated material can be loaded into transport units on either side, or it can be piled on the ground. The designed capacity of the machine is 40 net tons per hour, with a probable average of 30 tons per hour.

The peg tooth drum and air blast principle was chosen for this machine after considerable experimentation with the suction drum principle. The aim of the project is a more conclusive determination of the maximum efficiency of a portable dry cleaning machine. The equipment is being mounted on a full trailer built to specifications, and if successfully developed, it can be moved about the harvest system advantageously.

HOWARD ROTARY HOE OPERATES WELL AT KEKAHA

The Howard "Rotavator" rotary hoe has been in operation during the year at Kekaha and has worked effectively in this plantation's paddy-type soils.

The 7-foot unit on a D-7 tractor also proved efficient for mixing trash and bagasse with the surface soil. Its operation usually follows that of their Storey "Gyrotiller" plow. A similar rotary hoe has been designed for Kekaha with an 8-foot cut to be attached to a D-8 tractor.

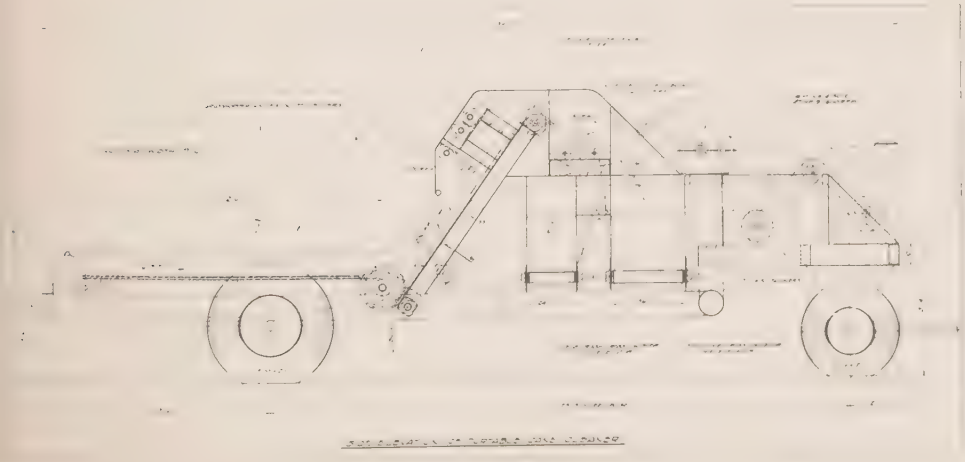


Figure 42. Side elevation of the portable cane cleaner which is being constructed and which will be field tested.

VARIETIES

STATION BREEDING PRACTICES ANALYZED AND EXPLAINED

During the year, members of the Genetics Department have devoted considerable attention to an analysis of past and present breeding practices. The purpose of this analysis has been to identify shortcomings in the current procedures and to devise, within the prevailing limitations of budget and personnel, revisions that might contribute toward more rapid progress in breeding. The conclusions are discussed in the following paragraphs.

Generation-wise selection: In planning his strategy, the sugar cane breeder may choose between two contrasting lines of attack.

(a) He may devote a major portion of his effort to evaluating breeding behavior of parent varieties. Having ascertained which of his varieties are superior as parents, he would then proceed to utilize these superior parents extensively in large-scale crosses.

(b) He may direct his emphasis toward recurrent (generation-wise) selection. This approach expends but little effort upon the repeating of crosses that have produced superior seedlings. Instead, the major emphasis is directed toward the prompt utilization of the superior new seedlings themselves as parents in further cross-breeding.

During recent years our breeding program has explored both of the above alternatives. While the evidence can hardly be considered conclusive, the results to date favor the second alternative.

Recurrent, generation-by-generation selection affords a tool by means of which gene frequencies may be shifted in the desired direction. The shorter the interval between generations, and thus the greater the number of cycles of selection realized within a given period of years, the more rapid the rate of progress, other things being equal.

The frequency of the generation-wise recurrence of selection can be speeded up only by reducing the duration of the inter-generation testing period. At this point opposing considerations are encountered. As the inter-generation testing period is shortened, the accuracy of evaluation both of phenotypic and of genotypic characteristics of the new canes must diminish. In such a situation, the breeder must aim at effecting the most advantageous compromise possible.

A study of the crossing record reveals that the average interval between generations in our most recent population of crosses, that of 1951, was nine years. We believe that this is too long, and that a reduction in the mean interval between generations to permit a greater number of generation-wise cycles of selection within a given period of years will prove to be a step in the right direction.

The "melting pot" method of crossing: The briefness of the tasseling season imposes a bottleneck upon sugar cane breeding in Hawaii. This bottleneck has been aggravated in recent years by reductions in the work day and the work week, accompanied by rising labor costs. These trends have necessitated the devising of procedures that would enable the limited personnel to accomplish a reasonable volume of crossing during the six-week tasseling season.

The melting pot procedure is proving a useful tool in this respect. It achieves a wide diversity of combinations among selected parent canes at a fraction of the cost of a corresponding volume of bi-parental crossing. The chief drawback of the method is that the male parentage of the resulting seedlings cannot be known. This disadvantage may be more illusory than real. Lack of information as to the paternity of a superior seedling in no way precludes its utilization either as a commercial variety or as a parent in further breeding.

Information as to paternity is indispensable in a program that emphasizes the repeating of the particular crosses that yield superior seedlings. However, as has been pointed out, experience indicates that greater progress can be realized from the utilization of the superior new seedlings themselves in further crossing than from repeating the crosses that produced those seedlings.

A comparative study of the results of melting

pot and bi-parental crossing shows that while a considerably higher proportion of the man-hours available during the all too brief crossing season is devoted to bi-parental crossing than to melting pot crossing, the bi-parental crosses are yielding less than one-fourth of the total number of selectable seedlings.

In spite of this discrepancy, bi-parental crossing has been and must continue to be employed in the crossing program to effect specific combinations of high priority. It appears, however, that further gains may be realized from a more extensive utilization of the melting pot procedure. A special melting pot of parents selected for their tolerance for mauka conditions has been a feature of the breeding program since 1949. Other melting pots for specific purposes have been employed from time to time. It is now proposed to initiate additional melting pots for special conditions, such as those in the Hilo district and the leeward irrigated districts.

Genetic diversity: An analysis of selection rates shows that certain parents produce progenies containing higher than average proportions of selectable seedlings. 39–7028* is an outstanding example; it stands at the head of the list of today's superior parents. Others that rank high are 37–1933, 37–7202, 39–723*, 39–3633*, 39–4753, 39–5747*, 39–5760, 39–5803, 40–1184*, 41–1181*, 41–3340, 41–3620*, 41–3817, 43–1006*, 43–1616*, 43–1884*, 44–1117*, 44–2818*, 44–3098* and 45–2120*.

There can be no doubt that in the immediate future, a higher proportion of commercial candidates would result from restricting the breeding program to the elite parents listed above. It is probable, however, that such a course would result in the early onset of a curve of diminishing returns. Many new blood lines not included in the above list remain to be explored for genes that may be able to contribute to higher yields under our various climatic and soil conditions. While some, and perhaps most, of these new lines will prove disappointing, a small minority may be expected to contribute new traits of value or genes superior to those now available.

The negative factors with which the crop must contend are not static. In the absence of crop rotation, the microbial pathogens in particular are likely to live up to their reputation of being shifty enemies. While it may not be inevitable that the hitherto resistant standard varieties must eventually succumb to new and more virulent strains of one or more of the pathogens, such an occurrence is not unlikely.

In view of the wealth of evidence pointing to the dynamic nature of the pathogen complex, it is hardly to be expected that the breeding program could well be planned in detail far in advance. Some of the negative factors that will have to be dealt with 10 years hence may not yet be present. Strict adherence to a preconceived program narrowly based upon lines which, in the light of past experience are believed to be most promising, may result in a reduction of effectiveness in meeting changing selection standards and in failure when confronted with a new negative factor.

Guiding principles can, however, be formulated. Chief among these is the axiom that the greater the genetic diversity of the population the greater the likelihood that it will contain individuals resistant to whatever negative factors may assert themselves.

The Genetics Department feels that it would be unwise to aim at the short term goal of more rapid immediate progress such as might be realized by confining the breeding program to what is believed at the moment to be the most promising crosses. The sacrifice of genetic diversity which such a course would entail would be too great a price to pay for a temporary advantage.

Insurance value of large numbers: The present standard varieties, such as 37–1933, 38–2915, 39–3633 and 44–3098, represent selections from populations totaling several million seedlings. The chances of finding something still better among a population of only a few thousand seedlings would appear to be discouragingly low. Other things being equal, the larger the number of seedlings that can be examined, the greater the chances of discovering still better canes.

By selecting more rigorously and by eliminating the mediocre seedlings more promptly, it has become possible for the regional stations to accommodate larger numbers of new seedlings each year. However, the department feels that movement in this direction has been too slow. A further increase in the number of combinations made per season would accelerate the tempo of generation-wise progress of the breeding work, since more of the

*Seedlings resulting from melting pot crossing.

new varieties would then be used as parents at an earlier stage, thus expediting evaluation for breeding purposes. Moreover, an increase in the total number of seedlings will tend to improve the chances of combining rare and desirable traits such as light tasseling, second-season growth, and carrying-over ability with other desirable traits. It is the belief of the Genetics Department that a wider diversity of crosses to produce still larger numbers of seedlings to be subjected to even more rigorous selection will result in more rapid progress.

During recent years, the number of seedlings that could be grown has been limited by the available greenhouse space. The new greenhouse, authorized last May by the Experiment Station Committee, will increase the facilities by more than 50 per cent. In addition to permitting an increase in the number of seedlings, the new greenhouse will make it possible to plant the fuzz more promptly after harvesting, thus reducing the loss of viability which occurs when the fuzz must be held in storage. It will also be helpful in getting the seedlings transplanted to the field early enough to permit the heavy tasselers to tassel, thus facilitating selection for freedom from tasseling.

Selfing as a breeding tool: A study of the possibilities of selfing in sugar cane breeding has been under way at this Station for more than 25 years. Selfing is an important step in the breeding of naturally cross-fertilized crops which cannot be asexually reproduced from cuttings nor by budding or grafting, and which must therefore be grown from true seed. The revolution in corn breeding which began more than 30 years ago was based upon the finding that certain weak inbred lines when crossed together were able to produce vigorous, uniform progeny. The uniformity of the hybrid offspring stems from the fact that repeated selfing had rendered the inbred parents homozygous. A homozygous individual produces germ cells (pollen and egg cells) that are genetically uniform. When two such uniform true breeding parent lines are crossed, the typical result is a vigorous uniform hybrid population, each member of which is genetically identical with its sisters.

This very uniformity among the progeny, which confers such a great advantage in crops that must be grown from seed, is a liability in the breeding of crops that can be propagated asexually. Obviously there is less likelihood of finding, in a genetically uniform population, one or several outstanding individuals possessing high resistance to the many negative factors in the environment, than would be the case in a population with a similar mean but with a high degree of genetic variability.

Added to the disadvantage of loss of genetic variability which the selfing approach entails, is its costliness in terms of time. The bringing together in a single individual of the desirable traits of four grandparents requires a minimum of two generations of crossing. If the interval between generations is eight years, then even in the absence of selfing, 16 years would be needed to achieve a synthesis of four parent lines and to evaluate the progeny. Under a program which requires self-pollination of the four grandparental and the two parental lines before combining them in crosses, the time required to achieve the desired synthesis would be doubled. Under such a program, the industry might still be without the equivalent of 37–1933.

The results from selfing thus far obtained indicate that greater returns per dollar expended are to be realized by using the heterozygous parent lines themselves in crosses, than by first selfing these parent lines in preparation for subsequent crossing. It is planned, however, to continue the exploration of selfing as a breeding procedure in order to obtain further information on this question.

SUGAR CANE TASSELING INHIBITED BUT NOT INDUCED

The lighting experiments at Makiki last fall confirmed the fact that a 10-day lighting period is sufficient to suppress flowers permanently. Shorter periods of three to five days are not very effective, although they may have a measurable effect.

Again maleic hydrazide at the 3 per cent and one per cent levels brought about a reduction in flowers without any measurable loss in stalk weight six months later.

The Departments of Physiology and Biochemistry and of Genetics have been cooperating in an effort to induce early flowers in the varieties 37–1933 and 32–8560. Plots of vigorous cane were enclosed by dark boxes with removable tops and sides. Starting on August 1, 1951, the day lengths were shortened to correspond with those of September by closing the boxes before sunset and reopening them after dark. Under this treatment,

Figure 43. Flowering is inhibited by enclosing plants in dark rooms for a short period each evening before sunset during August and September. Variety 37-1933 is shown on the left; 32-8560 on the right.

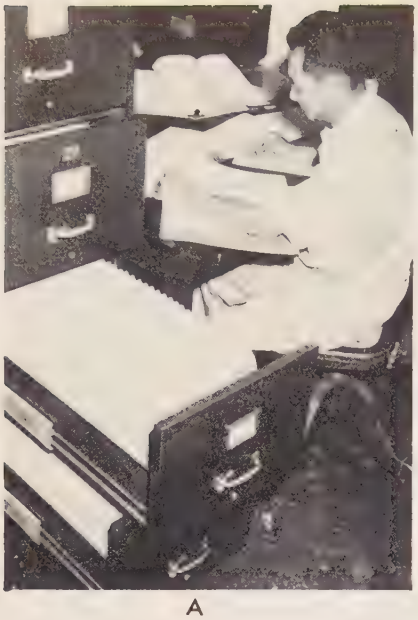
the temperatures were normal except for a brief period of about two hours each evening. The photographs in Figure 43 taken on January 15, 1952, show that instead of inducing early flowers, this treatment inhibited all flowering.

Figure 44 shows large concrete pots containing seven non-flowering varieties and 37–1933 loaded on cars which were rolled into a dark house every night. The 144 pots were divided into six groups, each variety being in triplicate. By rolling the cars out of the dark house at half-hour intervals in the morning, the groups received the following day lengths from September 1 to October 14: normal day (N); N - ½ hour; N-1 hour; N-1½ hours; N-2 hours; and N-2½ hours.

While no flowers were induced in the non-flowering varieties, flowering was inhibited in all plants of 37–1933 except in those left outdoors under normal conditions.

This extreme sensitivity of sugar cane to climatic conditions is further illustrated by the results from the climate houses, where heavy flowering varieties flower only in the normal Makiki climate. Raising or lowering the temperature of the night or of the entire 24-hour period completely inhibits flowering.

Figure 44. In an effort to induce flowering of non-flowering varieties, cars loaded with pots of sugar cane stand ready to be rolled into the dark house shown at the left. The cars are rolled out at half-hour intervals in the morning.



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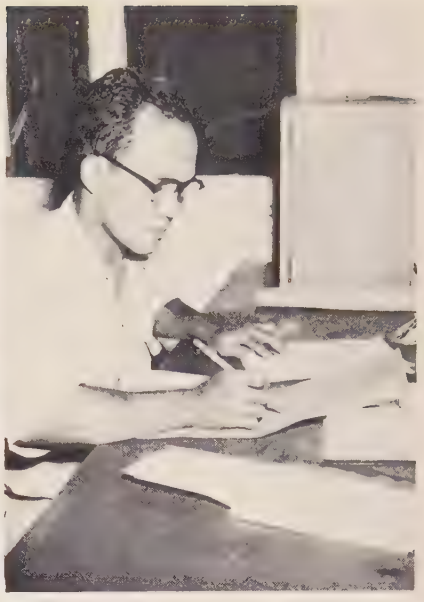
B



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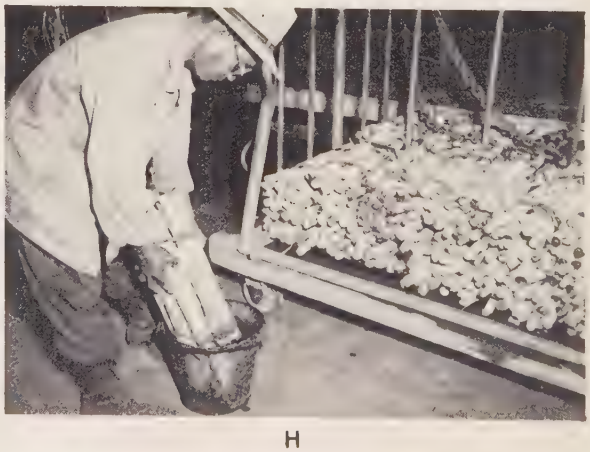

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Figure 45. A 10x15 Seed Order Is Processed

The 10x15 stage in the seedling testing program usually marks the beginning of plantation participation. Requests for 10x15 candidates for a particular plantation field or area are processed in the office of the Genetics Department or of the Island Representative.

A. First, using the Master File which includes all the notes, gradings, and harvest data on every planting of every seedling in the active tests, a list of the most promising candidates is compiled and a seed shipment order is prepared.

B. Tags for each listed seedling are made at Waipio Substation on Oahu, where the nurseries are maintained which are the primary source of seed for 10x15 plantings. Seed nurseries are also maintained at some of the other Variety Stations.

C. Field maps are marked to facilitate seed cutting.

D. Using the maps, the seed cutting crew locates the proper plots.

E. After the plots have been carefully checked to establish identity and to eliminate mixtures, healthy stalks are selected and cut.

F. The seed bundles are tagged and secured with heavy rubber bands.

G. In order to kill insects and to inactivate pathogens, the seed bundles are given the hot-water treatment: a 30-minute bath in water heated to 50°C.

H. The ends of the seedpieces are dipped in a fungicide solution, phenylmercuric acetate.

I. The bundles, surrounded by shavings, are firmly packed in standard seed cartons to prevent damage to the eyes.

J. While the seed bundles are being packed, the final Shipping List is prepared in the office.

K. The cartons are sealed and addressed.

L. A truck delivers the cartons either directly to the plantations or to the dock for shipment to the neighbor islands.

MANY NEW CANES IMPORTED FOR BREEDING PURPOSES

Among the varieties released from the importation program in mid-March was Trojan. Because of the keen interest in Trojan, resulting from its outstanding performance in Australia and its promising appearance when grown on virgin land in the quarantine field on Molokai, this variety was distributed directly to all plantations.

Released at the same time as Trojan were a number of breeding canes and several other possible commercial candidates now in observation plots at the variety stations. This latter group includes P.R. 905 (Puerto Rico), Mauritius 134/32, D 14/34 (British Guiana), Co. 419 (India), and B 41211 (Barbados).

Still in quarantine, but due for release in March, 1953, are B 37172, B 41227, B 4362, Comus (Australia), M 336 (Puerto Rico), Pindar (Australia), Q 50 (Australia), and a number of breeding canes. In the 1952 importation are B 3337, B 43391, B 44341, Co. 313, Eros and Vesta (Australia), Pepe Cuca (Cuba), all of possible commercial interest, and several varieties of purely breeding interest.

Seed of many of the more important commercial varieties of other countries is available in the Station seed nurseries and can be supplied to plantations wishing to plant museum or demonstration plots.

The coming crossing season promises to be one of unusual interest. The breeding plots at the Kailua Field Laboratory contain a wealth of new material including the following:

Trojan—the leading variety of Queensland.

M 134/32—the leading variety of Mauritius.

Q 47—resistant to Fiji disease and downy mildew in Queensland.

Tekcha—a Uba type from Okinawa.

Co. 419—a commercial variety in India.

C.P. 44/101—a new commercial variety in Louisiana.

Hybrids of the following canes will be available for the first time this season for further backcrossing with local varieties: BH 10/12, B 37161, B 34104, African spontaneum, Burma spontaneum, Sumatra 2, Uba Marot, POJ 3016, POJ 2967, F 108, and Saipan 17.

Of even greater immediate promise than the foreign material listed above are the many seedlings of 37–1933, 39–3633, 39–7028 and 44–3098 in the breeding plots. We hope to be able to use this new material in a wide diversity of crosses during the coming season.

SEEDLINGS FROM 1951 FUZZ IMPORTATION NOW IN QUARANTINE FIELD IN MOLOKAI

Seed (fuzz) received from New Guinea, Australia and Fiji in 1951 as a result of Dr. Warner's visit to those regions, was germinated in the Mapulehu quarantine house.

Following a rigorous inspection in March, 1952, cuttings were planted in a quarantine field for another year's observation. The material includes seedlings from fuzz of wild relatives of sugar cane collected in New Guinea, and from fuzz of crosses made in Australia utilizing blood lines not available in Hawaii. A few seedlings represent some fuzz collections made in Fiji from both wild and noble canes. After being released from quarantine, which will not be before March 1953, the seedlings will be sent to the Kailua Field Laboratory for use in the breeding program. Canes of commercial type may also be sent to key regional stations.

OVER 3,000 CROSSINGS MADE IN 1951–52 CAMPAIGN

Last season's crossing campaign was begun on November 19, 1951, and was concluded on January 3, 1952. The number of crosses completed during the season is shown in Table V.

Weather during the crossing season was exceptionally favorable, particularly from the standpoint of the complete absence of destructive wind storms. Germination of harvested fuzz was normal, and the number of seedlings propagated was the largest in the history of the industry.

REGIONAL VARIETY STATIONS OPERATES AT FULL CAPACITY

Under the supervision of the Island Representatives, the regional stations are operating at full capacity.

Table VI shows the magnitude of each stage of preliminary testing at each of the regional stations. Seedlings which show promise at the regional stations are distributed to the plantations for 10 x 15 and 30 x 30 testing.

TABLE V

Number of Crosses Completed During 1951-52 Crossing Season

General melting pot crosses	1,429
Mauka melting pot crosses	170
Super melting pot crosses	362
Wild melting pot crosses	51
5 x 6 melting pot crosses	66
Bi-parental** crosses	668
Selfs*	18
Field crosses	152
Field crosses (collected at Molokai)	84
Inter-generic crosses	21
Total	3,021

*Includes 7 collected as field selfs.
**8 crosses for Australia not included.

TABLE VI

Plantings Made in 1952 at Regional Stations

Regional Stations	No. of Flats (No. of seedlings per flat 100 to 1,000)	5 x 3 No. of Sdlg. Plots	5 x 6 No. of Sdlg. Plots	10 x 15 No. of Sdlg. Plots	30 x 30 No. of Sdlg. Plots
Kailua Field Laboratory	2,601	2,041	———	———	———
Waipio Substation	1,378	7,766	1,414	230	64
Waipio Mauka Variety Station	448	2,657	2,054	169	48
Ewa Variety Station	———	1,736	927	92	27
Helemano Variety Station	———	3,108	1,305	118	24
Hilo Variety Station	350	4,155	1,675	76	30
Hamakua Makai Variety Station	396	3,926	1,818	101	26
Hamakua Mauka Variety Station	———	2,555	1,406	67	26
Kohala Variety Station	178	1,229	1,505	78	24
Kau Variety Station	100	4,712	1,241	89	27
Maui Variety Station	363	———	869	122	20
Kauai Variety Station	325	2,719	1,357	140	38
Total	6,139	36,604	15,571	1,282	354

Note:

Breeding and spreading areas are not included in counts.
1,151—5x3 plots of "super selections" not included in counts.
Also not included are field nurseries and 5x3 plantings under special conditions on plantations.

Kekaha	230 flats	Kohala	588 (5x3 plots)
H. C. & S.	100 "	Hutchinson	1,171 (5x3 plots)
Kohala	100 "		
H. A. Co.	132 "		
Hutchinson	100 "		
	662 flats		

PRELIMINARY TESTING ON PLANTATIONS INCREASING

The volume of 10 x 15 and 30 x 30 testing on the plantations continues to increase year by year, as shown in Table VII.

It is this phase of the testing program that will bring to light the future candidates for Grade A testing.

TABLE VII

Number of Preliminary Tests Installed by Plantations
(For fiscal year ending June 30)

Type of Test	1947–48	1948–49	1949–50	1950–51	1951–52
10 x 15	50	54	62	70	92
30 x 30	30	41	47	50	71

REPLICATED TESTING ON PLANTATIONS STAGES A COMEBACK

Varieties included in replicated tests installed by the plantations during the fiscal year are listed in Table VIII. The number of entries totals 175, reflecting a partial recovery from last year's recession in the volume of replicated variety testing.

The list shows that 44–3098 was included in 45 tests, a majority of which were installed on the island of Hawaii.

38–2915 was included in 23 tests, 47-4991 in 22, and 45–2708 in 16 tests.

TABLE VIII

Replicated Variety Tests Installed by Plantations
July 1, 1951 to June 30, 1952

Variety	Kauai	Oahu	Maui	Hawaii	No. of Entries Total
32–1063	—	—	—	1	1
8560	1	1	—	9	11
37–1933	3	5	1	1	10
38–2915	4	3	1	15	23
4443	—	—	—	3	3
4744	—	—	—	1	1
39–3633	2	—	—	7	9
4753	—	—	—	8	8
7028	4	1	—	3	8
41–3340	—	—	—	3	3
4084	—	1	—	—	1
44–2507	1	—	—	—	1
3098	12	6	1	26	45
45–369	—	—	—	3	3
2120	—	—	—	1	1
2708	7	3	—	6	16
46–551	—	—	—	5	5
564	—	—	—	3	3
47–2060	—	1	—	—	1
4991	8	2	—	12	22
Totals for:					
1951–52	42	23	3	107	175
1950–51	32	7	0	108	147
1949–50	86	19	5	89	199

NEARLY 6,000 PLOTS PLANTED WITH SEED FROM VARIETY STATIONS

The distribution of seed of selected seedlings by the regional stations to the plantations is detailed in Table IX. The distribution of seed for 10 x 15 testing reached a new high with a total of 5929 plots for the fiscal year. Figure 45, on pages 50 and 51, shows how a seed order is processed.

TABLE IX

Seed Shipments From Experiment Station Nurseries

July 1, 1951 to June 30, 1952

Source	For Seed Nurseries in Preparation for Replicated Tests—Tons	For Other Seed Nurseries Tons	For Grade A Tests Tons	For 10x15 No. of Plots	For 30x30 No. of Plots
Kailua Field Laboratory	—	6.08	.17	—	2
Waipio Substation	.75	4.67	—	3,285	13
Ewa Variety Station	—	7.87	—	16	—
Helemano Variety Station	—	—	—	1	7
Maui Variety Station	—	.30	—	132	—
Hilo Variety Station	20.05	43.70	7.05	718	2
Hamakua Makai Variety Station	.38	2.01	1.70	1,021	1
Hamakua Mauka Variety Station	—	.33	—	219	—
Kohala Variety Station	—	1.02	—	91	—
Kau Variety Station	—	—	—	418	—
Kauai Variety Station	—	—	—	28	4
Totals	21.18	65.98	8.92	5.929	29

SEEDLING PARADE FOR 1952

38–2915 has come through with good field yields in the upper lands, both in the irrigated and unirrigated districts. It is also proving to be a difficult cane to beat in certain of the Central Maui lowlands, where 37–1933 does not thrive. It is a slow starter, both in plant and ratoons, but once closed in, it maintains a good cover. There have been reports of difficulty under mechanical harvesting due to the breaking up of the stalks into short lengths, resulting in high cleaning plant losses. It has also been reported that the fuel value of the bagasse is below par.

When well ripened, the juice quality of 38–2915 has been satisfactory. Its over-all quality ratio tally, however, is on the poor side. (Good 16, Average 254, Poor 103)

39–3633 has staged a partial comeback in the makai lands of the Hilo district, after having fallen into disfavor as a result of poor germination and gappy stands in late-planted fields. This return to favor has resulted from a growing appreciation of the advantages which this variety has to offer in the way of strong ratooning, good stalk diameter and relative freedom from tasseling. 39–3633 remains a strong competitor also in the middle and better mauka lands of windward Kauai. The Q.R. tally of 39-3633 (Good 58, Average 245, Poor 65) is similar to, but not quite equal to that of 44–3098.

39–7028 is still being planted in the poorer mauka unirrigated lands of windward Kauai. Under these difficult conditions, its freedom from tasseling and its ability to come through with good yields under long cropping outweigh the disadvantages of slow starting in plant and ratoons. 39–7028 ripens fairly well under long cropping in the poorer mauka lands. Under short cropping and under good growing conditions, poor juices are frequently encountered. Its over-all Q.R. tally stands at Good 11, Average 143, Poor 78.

There is need for a better variety for this region, one that combines the advantages of 39–7028 with better juices, more reliable germination in plant, and stronger ratooning. It is hoped that one or more of the new canes now in preliminary trials will meet these requirements.

44–3098 continues to come through with substantial gains over 32–8560 and 32–1063 in the unirrigated districts. From the few ratoon har-

vests thus far reported, it appears that its relative standing in ratoons will not differ greatly from that of the plant crop. In the mauka lands of Hamakua, it is running into stiff competition from 38–2915. In the makai lands of the Hilo district, 39–3633 is a strong competitor. In general, the results from the few fields harvested thus far tend to support those from replicated tests.

The quality ratio tally of 44–3098 now stands at Good 51, Average 102, Poor 40.

45–2708 continues to show promise in the heavy tasseling middle and makai lands of Hilo and Windward Kauai. Its relative freedom from tasseling and its ability to carry over in sound condition under two-year cropping should prove particularly advantageous under a January to April start. It is this cycle which makes for heavy first-season tasseling and poor yields in heavy tasselers such as 32–8560 and 37–1933. 45–2708 also offers the advantages of strong ratooning and good juices. Its Q.R. tally reads Good 12, Average 27, Poor 4.

45–2708 appears to be too sparse and open for the poorer mauka unirrigated lands. Whether it will be able to compete with 38–2915 and 44–3098 in the mauka irrigated lands is still to be determined.

Mosaic disease has been found on 45–2708 at Paauhau. Several cases of leaf scald were found at Pepeekeo. No disease symptoms have been noted elsewhere.

Other seedlings worthy of brief mention are:

39–4753—a stand-by variety for the middle belt of Hamakua and Kohala.

39–5760—a stand-by variety for mauka Hamakua and Kohala.

41–3340—worthy of further testing in droughty makai unirrigated areas.

44–1148—a candidate for testing in middle and mauka Hamakua and Kohala.

44–2772—a candidate for testing in middle and mauka Hamakua and Kohala.

44–3171—a good juice cane for testing in Hilo middle belt.

45–2120—a stand-by cane for makai windward and mauka leeward districts.

46–359 —a candidate for testing in mauka Hamakua and Kohala.

46–564 —a candidate for testing in mauka Hamakua and Kohala.

46–611 —a non-tasseler for testing in the makai irrigated lands of windward Kauai

46–945 —a candidate for testing in the makai flats of leeward irrigated districts.

46–2404—worthy of further testing in leeward irrigated districts.

47–2060—worthy of further testing in leeward irrigated districts.

47–2800—worthy of further testing in leeward irrigated districts.

37–1933 REPLACES 32–8560 AS LEADING CANE

The Acreage Census of December 31, 1951, shows that 32–8560 has dropped to second place after having held the leading position in terms of total acreage for 10 years. The new leader is 37–1933, which at the time of the census occupied 64,609 acres, representing nearly 30 per cent of the total sugar cane area, and reflecting a gain of 8760 acres during 1951.

The area occupied by 32–8560 has declined to 50,526 acres representing a loss of 24,432 acres during the year. This loss reflects the replacement of 32–8560 by 37–1933, 38–2915, 39–3633, 39–7028 and 44–3098. It is interesting to note that all of these varieties are seedlings of 32–8560.

In terms of new plantings, 44–3098 was the leader with 17,882 acres, or more than 40 per cent of the total area planted during 1951. 37–1933, with 11,885 acreas and 38–2915, with 5539 acres, stood second and third, respectively, in the list of plantings for the year.

WATER DEVELOPMENT

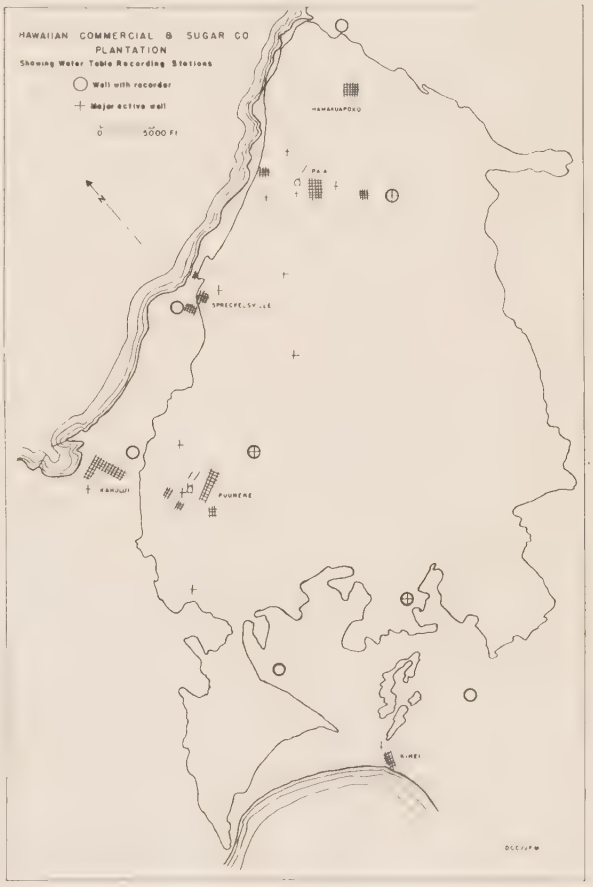
BASAL-WATER DATA IMPROVED

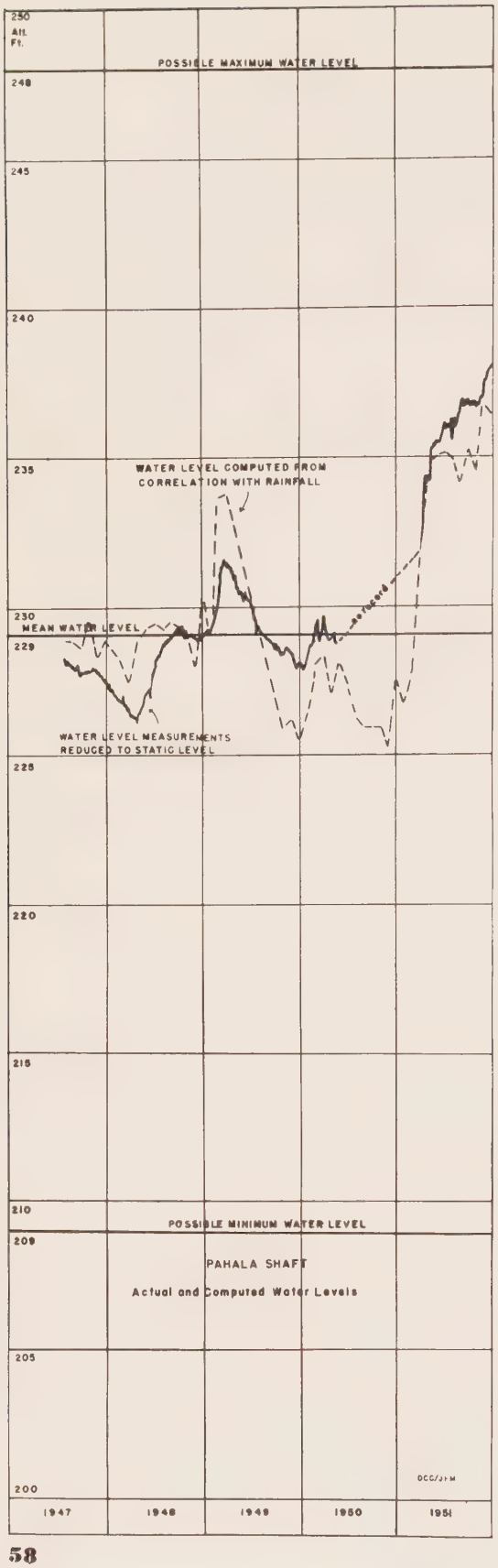
Quantitative estimation of the safe yield of basal ground-water bodies of the Ghyben-Herzberg type is difficult at best, because of the complicated hydrology, involving a lag in bottom storage changes behind head changes. Estimation is impossible where the basic data are inadequate or unreliable. In several areas, collection of data has been so improved that the records can be used with confidence as far as theory permits.

Maui: On the Maui Isthmus, the collection of data was improved because of an immediate practical objective. Since late 1951, through arrangement with the Territory, government water in the East Maui ditch country has been exported to the Maui Isthmus free of charge whenever it was not needed for irrigation. This water has been spread through the reservoirs of H. C. & S., and the excess has been allowed to flow into streams in an effort to recharge to a maximum the Maui Isthmus ground-water body on which wells with a total capacity of nearly 250 million gallons per day depend. Though the costs of operating the ditch system to transport and spread the water are not large, and though the results of the artificial recharge will probably be more than adequate for their qualitative justification, a quantitative evaluation is also desirable. Heretofore, the only systematic measurements of head in the Maui Isthmus have been annual readings on certain wells. These have been subject to certain inaccuracies. At best, annual measurements cannot indicate seasonal changes, and single measurements, in an unconfined body like that of the Maui Isthmus, are subject to tidal errors that are very large in comparison with the head.

Eight wells, spread over the Isthmus as indicated in Figure 46, have now been equipped by the East Maui Irrigation Company with water-stage recorders to measure the head. All of the wells show tidal fluctuation, but the continuous records will permit analysis and averaging out or correction for it. As far as possible, the wells selected are not pumped and are distant from major pumping plants. However, in order to get measurements in the mauka area, it was necessary to use active wells. Again the continuous records will permit analysis of and allowance for the drawdowns. Monthly, or as necessary, more frequent values of static head for each well will be computed and compiled as a record of top storage changes for correlation with rainfall, artificial recharge, and draft. Methods of estimating bottom storage changes have yet to be worked out, but approximations of these changes may be made possible by an analysis of the propagation of tides from the ocean to each well. To check the approximations, deep test holes, penetrating the zone of salt mixture, will be desirable in the future.

Figure 46. Water recording stations on H. C. & S.





Oahu: The Kahuku basal ground-water body on Oahu is probably the most critical in the Islands with regard to salt encroachment and overdraft at the present head. To implement future studies of the hydrology of this body, records of the existing head, salinity, and draft have been completely compiled with the assistance of the Geological Survey.

Hawaii: The longest and most complete record of the head in the basal ground-water body of the Hamakua Coast of Hawaii is that at the Ookala Shaft, and its value was negated by uncertainties and changes in the datum used. New levels have been run down the shaft establishing a good sea-level datum, the datum of older records has been identified and tied in, and continuous recor-d ing to permit tidal averaging has been started.

WATER-TABLE FLUCTUATES AT PAHALA

Raising the pumps in the Pahala shaft on Hawaii was necessitated a year ago by a rise in the water table far above its already unexplained initial high level of 228 feet above sea level in 1947. An analysis of the effect of variation in rainfall on the water level in the shaft has been made using a Wentworth type of time-debited rainfall index. The effects of pumping appear to be so small and the average rate of pumping so nearly constant that, except for correlation of measured head readings for drawdown, draft effects have been neglected. The best correlation has been with a monthly rainfall index using the Alili Tunnel and Pakao rain gauge readings debited one per cent per month with a one month lag. The results, shown in Figure 47, do not justify confidence in the accuracy of a prediction of head. The standard error of estimate of the head is 1.4 feet for the period of correlation, but the errors in prediction may be expected to exceed this. However, as a crude guide to the expectable range in static water levels, the correlation has some value. The head corresponding to the highest rainfall index for the period of rainfall record (since 1929) would probably be 246 feet above sea level and might be a foot or two higher. This level is higher than the pumps, even in their relocated positions. The head correspond-

Figure 47. Measured water levels at the Pahala shaft are here compared with water level estimates computed from rainfall.

ing to the lowest rainfall index for the period of record would probably be 212 and might be 209 feet above sea level, which is about at the limit of suction lift for the two centrifugal pumps in their present position, and which would be too low if they were lifted to allow for the maximum level. Despite the present inadequacies in the correlation, it seems highly probable that the Hawaiian Agricultural Company will have to raise its pumps again at some time in the future, and will either have to replace the horizontal centrifugals or prepare to move them up or down every few years.

WAINIHA INTAKE AREA STUDIED FOR POSSIBLE UNDERFLOW

The entire low-water flow of the Wainiha River on Kauai is diverted by a low dam into a ditch-tunnel system that transports it about six miles downstream to the penstock of the Wainiha power plant of the McBryde Sugar Company. However, seven million gallons of water per day appear in the half-mile course of the river immediately below the intake. In an effort to determine whether or not part of this water is underflow in the gravel of the valley, and if it is, how it might be forced into the ditch, a study has been made of the geology and hydrology of the intake area, based largely on three diamond drill holes. The holes indicate that bedrock lavas of low permeability lie only about 30 feet below the valley floor as shown in Figure 48. The gravel in the valley is of two ages. The permeability of the older, as indicated by recharge and pumping tests on one of the test holes, is so low that it cannot transmit a flow of any consequence. Recharge and pumping tests on the two holes in the younger gravel suggested that while the flow is considerably smaller than that appearing downstream, it is of the same order of magnitude. However, Slichter tests, involving introducing salt water in one of the holes and timing its movement downstream past the lower hole, suggested that the flow is just as large as that appearing below. Measurements of flow rates and studies of seepage points and sections downstream, indicate that much of the flow downstream cannot be derived from the younger gravel. However, there seems no reason to believe that all of the underflow in the younger gravel is forced to the surface. To summarize, the tests to date indicate that an appreciable quantity of water is flowing at shallow depth in part of the gravel section at the intake, and that while it may be equal to the flow appearing downstream, it is not entirely the same water. Unfortunately, the minimum flow rate that could be economically recovered at the intake is probably in the range of uncertainty that can be reduced only by further testing. The methods developed can be used and may also have application elsewhere, as, for example, in Iao Valley on Maui where Wailuku is interested in the recovery of perched water for mill supply.

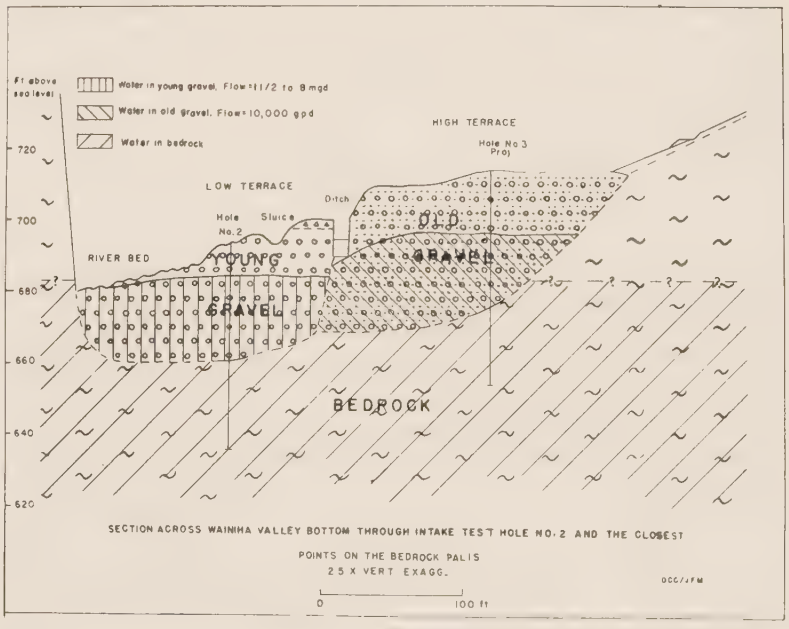


Figure 48. Section across the bottom of the Wainiha Valley through intake test hole No. 2 and the closest points on the bedrock palis.

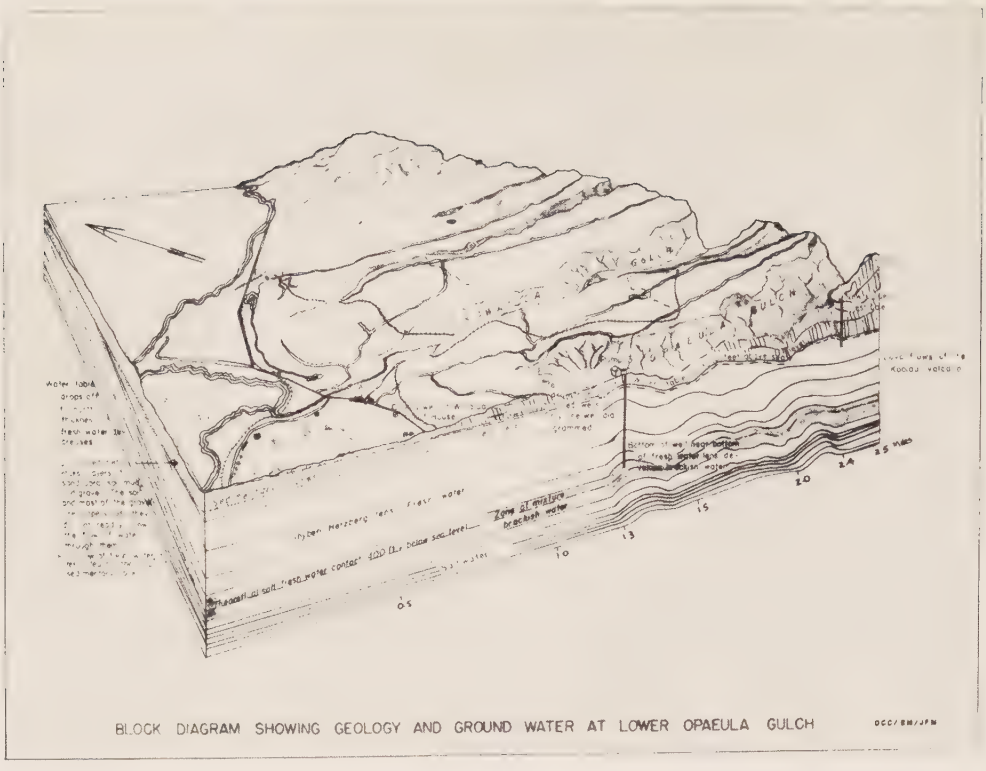


Figure 49, Geology and ground water at lower Opaeula Gulch.

NEW WELLS PROPOSED ON MAUI AND OAHU

The Puunene power plant of H. C. & S. requires nearly 15 million gallons of water per day for its condensers. This water, drawn from a Maui-type well, is passed through the condensers, and then used for irrigation.

As a proposed increase in power capacity will require an additional 10 mgd. supply, the geology and hydrology of the existing well were studied to determine whether the extra supply could be developed there or in the vicinity. The present nominal 15 mgd. supply is actually not quite met by the present well because the effective drawdown is limited by the shallow depth of the more productive of the two tunnels. This limitation of capacity can be easily overcome by lowering the flow of the tunnel. However, some 200 feet of new tunnel will be required to provide the additional 10 mgd. supply. To avoid the problem of hoisting the resulting muck up the present small shaft which is already filled with pump columns and pipe lines, it is planned to dig an entirely separate well about 400 feet away.

PROPOSED OPAEULA WELL

Following recommendations made by the Department of Geology in 1949, a diamond drill hole has been made by Waialua in Opaeula Gulch about a mile upstream from the present Pump 3 as shown in Figure 49 in order to ascertain if the Koolau lavas are of sufficient permeability to yield 14 million gallons per day with a moderate drawdown to a Maui-type well with tunnels of moderate length. The test hole indicated: 1) that the top of the section below the bottom of Opaeula Gulch is weathered to a depth of 100 feet, so that the upper part of a shaft sunk through it must be lined; 2) that water is perched in the alluvium of the gulch and that some pumping may be required in sinking the upper part of the shaft; 3) that the water table stands nearly 12 feet above sea level; and 4) that the lava flows are sufficiently pervious to encourage the construction of a Maui-type well.

Development of 14 million gallons per day at the proposed well will relieve the demand on Pump 3, which draws its water from a battery of deep drilled wells, all of which have been showing a progressive salt increase. With the reduced draft, and possibly some plugging back, the present wells should continue to give satisfactory service for a long time. The new well will also permit abandonment of very long pipe lines from Pumps 3 and 4.

PROGRESS MADE IN ARTIFICIAL RAINFALL STUDIES

During the past year, a greatly intensified program of cloud physics work has been carried out pointing toward the production of artificial rainfall from clouds under Hawaiian conditions, and toward improved weather forecasting.

The objectives of this work are to learn in detail, if possible, exactly how natural rain forms in tropical conditions and whether or not some of the factors which control rainfall are in themselves controllable.

These factors are the number, size, and nature of condensation nuclei which are the particles of dust, smoke, and sea salt on which cloud droplets form, the size of the tiny water droplets in the clouds, the strength of the wind, the temperature at different altitudes in the cloud layer, and the amount of moisture in the air.

Since one cannot hope to control the strength of the wind, the air moisture content, or the air temperature, emphasis has naturally been placed on learning everything possible about the nature of the condensation nuclei and how they act, and also about the importance of the size of the tiny water droplets within the clouds.

The most important factor seems to be the salt content of the air. When the bubbles produced by the white caps and surf of the sea break, they throw microscopic particles of sea water up into the air. Evaporation of these tiny droplets leaves salt crystals which are carried to high altitudes by the winds. Because these salt crystals, upon entering a cloud, take up moisture much more rapidly than do particles of dust or smoke, they form an important link in the formation of rainfall.

For this reason, special techniques and instruments (Figure 50) have been devised to measure the salt content of the air, and a large number of measurements have been made. The salt content of the rain water has also been measured along with the sizes of both rain drops and cloud droplets. All these measurements emphasize the importance of the part played by this particular factor in controlling rainfall.

Preliminary experiments have been made to test the possibility of utilizing this knowledge to produce rainfall artificially by introducing salt sprays or powdered salt into the clouds. It is still too early to judge the practical possibilities of this

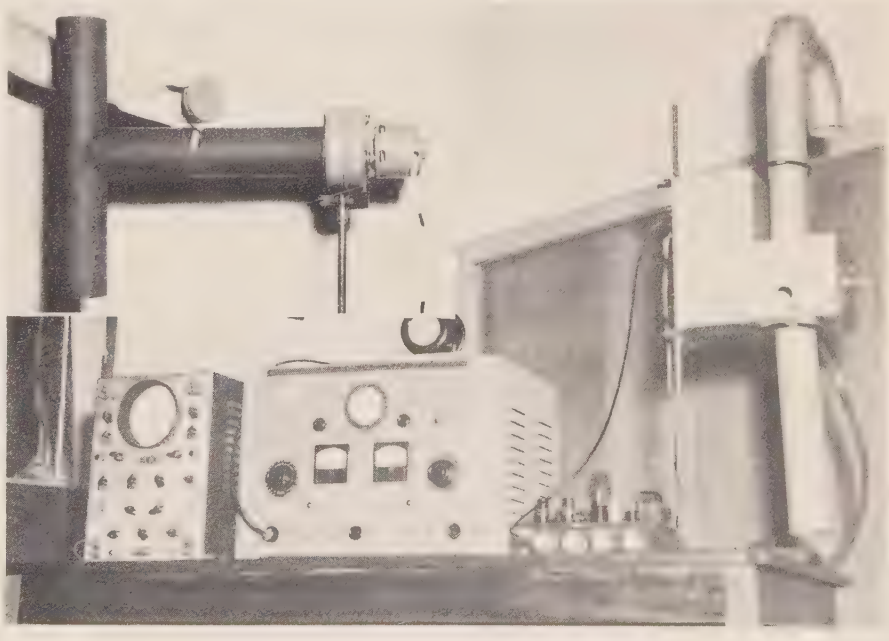


Figure 50. In connection with the cloud physics studies, the Meteorology Department measures the salt content of the air with the two special instruments illustrated. The first collects salt by drawing air through a tube by means of a blower. The salt particles, collected on a screen, are washed off and measured. The second instrument counts salt particles which flash in passing through a hydrogen flame. The flash is electronically recorded just as pulses are recorded in a Geiger counter.

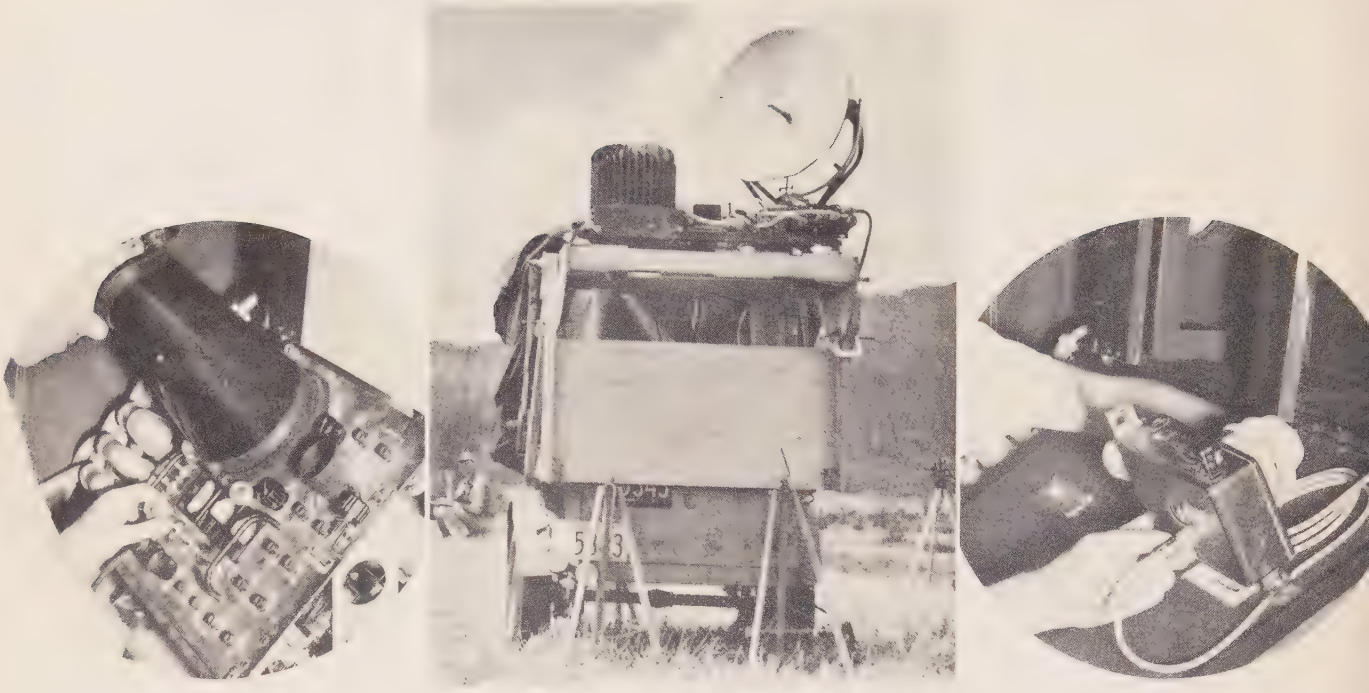


Figure 51. Three parts of the radar unit used to detect rain in clouds are here illustrated. In the center are the radar antenna and transmitter, mounted on a jeep trailer. At the left is the console of the receiver indicator unit. At the right is the automatic motion picture camera which provides a complete record by photographing the observations on the screen.

technique, but some very interesting results have been obtained.

Using a radar set (Figure 51) to detect the formation of large (.04 inch) droplets in a cloud, it has been possible in a rather large number of instances to observe large droplet formation within a few minutes after very fine sprays of sea water solution have been introduced into a cloud. Photographs of one of these experiments are shown in Figure 52.

Other experiments are using powdered salt dusted into a cloud from an aircraft and blown from the ground into a cloud. Delays caused by the shipping strike have made it impossible to make enough experiments and to amass a sufficient body of data to report on the results obtained.

INSTRUMENT DESIGN AND MAINTENANCE WORK INCREASE

A reorganization of metcorological activities at the HSPA the first of this year resulted in placing instrument work among the responsibilities of the Meteorology Department. Because of the interest in placing more weather recording instruments on plantations and the recent intensification of artificial rainfall experiments which require special instrumentation, a rather sharp upsurge of activity in this work has occurred.

The greatest effort has gone into meteorological instruments. Two radar units (Figure 51) have been installed in vehicles and have been operated in connection with the cloud seeding studies. Special instruments have been constructed to measure the number of salt particles in the atmosphere. One of these uses a hydrogen flame, through which air passes. When a salt particle passes through the flame, it makes a yellow flash which is seen by a photoelectric cell. These flashes are then counted by passing the electrical pulses through the circuits of a Geiger counter like that used for the measurements of radioactivity.

Other work has involved the checking of new meteorological instruments for plantations to see if they meet specifications and are properly calibrated (Figure 53). In this connection, the Meteorology Department advised the plantations on the best types of instruments to use for their purposes, helped to install them, showed them how to work up the data, and placed orders for new instruments. The instrument shop maintains the instruments used at the Experiment Station and at

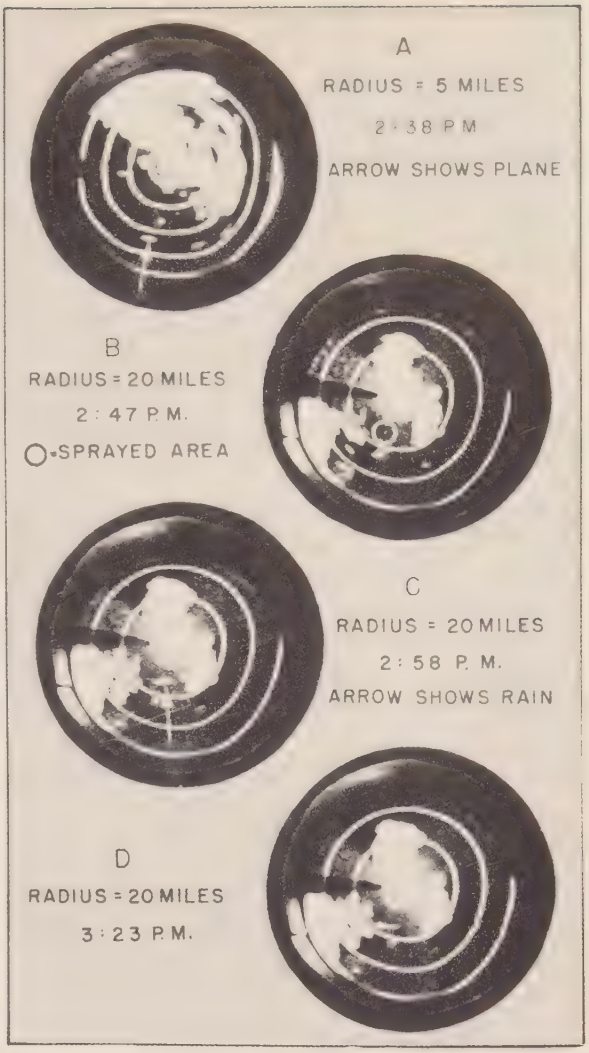


Figure 52. Four radar photographs tell the story of a cloud seeding experiment at Waimea, Hawaii, on March 24, 1952.

White areas in the photographs are reflections of solid objects or of rain. An airplane appears as a dot. Areas of rain also appear as white dots, while mountains show as large white splotches.

Suitable clouds were sprayed with very fine sprays of sea water, and the radar screen was watched for the appearance of rain in that same area. The whole area of the radar screen in A is the area covered by the smallest circle in B, C, and D. The distance between the perimeters of circles in A is one mile, while in B, C, and D, it is 5 miles.

In A, the large white area is Mauna Kea and the arrow points to the airplane, then about 3½ miles from the center.

B was taken 9 minutes later. The sprayed area is marked with a small circle. There were no rain images in the area at that time.

C, 11 minutes later, shows the rain image at the point of spraying. The two bright dots mark the two separate passes made through the cloud.

D, 25 minutes later, shows the rain image weakening and drifting away from point of seeding. The amount of rain induced is not known.

Figure 53. Before new weather instruments are sent to the plantations, they are checked at the Station. In the upper picture, a technician checks automatic rain gauges for Hutchinson and Hawaiian Agricultural Company. Below, new actinometers, which measure sunlight and soil thermographs, are being checked for proper calibration before going to Pioneer Mill, Hawaiian Agricultural Company and Hutchinson.

Waipio in the measurements of climatic factors which are needed for the experimental work.

The instrument technicians help, in addition, in many problems outside the Meteorology Department. In all, 52 jobs for plantations and departments of the HSPA involving the measurement of soil moisture, repairs of pH meters, repairs to mill recording instrument devices, construction of instruments for the HSPA spectrographic laboratory, construction of well-probing apparatus, etc., have been completed during the past nine months.

Many meteorological instruments now in use on the plantations are originally designed for a different purpose and different working conditions. Therefore, work is under way in the instrument shop to design and construct new apparatus which will give more satisfactory and economical service in measuring rainfall, temperature, and wind.

MONTHLY RAINFALL MAPS PREPARED FOR ALL THE ISLANDS

A project to obtain and plot average monthly rainfall figures from every rain gauge in the Territory is being carried out. Approximately 875 rain gauges are being currently read by the different plantations and agencies in the Islands. No maps, except for annual amounts, and these with limited data, have ever been prepared for the outside islands. Some of these records go back 65 years or more and the information they contain should be put into usable form. To do this, it was necessary to obtain approximately 200,000 monthly rainfall figures. Construction of the maps themselves has involved the calculation of about 12,000 average figures.

To help in forwarding this task, the meteorologists in the District Forecast Center of the U. S. Weather Bureau at Honolulu Airport offered their assistance. The maps for the islands of Oahu, Lanai, and Maui are completed; those for Hawaii and Kauai are partially done. Maps and tables of the data will be published for the use of the plantations and other interested groups.

NINE NEW AUTOMATIC WEATHER STATIONS ESTABLISHED ON SUGAR PLANTATIONS

A total of nine new automatic weather stations were established this year at Hawaiian Agricultural Company, Hutchinson, and Pioneer Mill. These stations have instruments for recording sunlight, air temperature, and soil temperature, and in addition, four stations at Hutchinson and Hawaiian Agricultural Company record rainfall with automatic gauges.

This increased weather information is intended to improve the crop log work on these plantations, and in the case of Hutchinson and Hawaiian Agricultural Company, the data will be used with an extensive age of harvest experiment.

Technical assistance in the location, installation, and care of these instruments has been provided by the staff of the Experiment Station. A large portion of the data has been worked up by the Meteorology Department to insure accuracy and to assist in launching the program promptly.

WEATHER FORECASTING RESEARCH POINTS TO PROGRESS

Most of the techniques used in forecasting rainfall involve the association by statistical methods of rainfall at one location with certain features of the weather map. These features may be migrating storms, or changing areas of low temperature or low pressure, which are known to be related to weather conditions at certain places. Many of these patterns, because of their motion, can be forecast.

The connection between these patterns and the rainfall, however, is usually not clear. In Hawaii, because short distances can make dramatic differences in climatic conditions, these weather patterns affect different areas in quite different ways.

As part of the weather research program this year, the weather patterns were studied in an attempt to learn how and when rainfall occurs. Ten days of concentrated effort was put into an observational program. The dimensions of the clouds were measured by aircraft along with temperatures, air moisture content, winds, air salt content, raindrop sizes, and times of showers. (Figure 54) Showers were tracked by radar to determine their intensity and motion.

A careful analysis of the information amassed has provided meteorologists with a better understanding and evaluation of the factors which control rainfall and should result in improved forecasting techniques.

Figure 54. The unusual effect in this view of clouds and rain over the Koolau Mountains of Oahu, is the result of the downward flow of air on the lee side.

NEW OILS IMPROVE CADE FORMULATIONS

Field tests run throughout the past year have proven the effectiveness of the two aromatic oils, 4276 (a combination of equal volumes of 4080 and 4470) and 55AR, which are used as replacements for Diesel oil. These new oils, now produced commercially and available locally, were developed specifically for use in CADE by two oil companies in cooperation with the Chemistry Department. They possess superior herbicidal values, since they contain 55 per cent of vigorous aromatic compounds and other weed-killing constituents which must be removed from Diesel oil. These two oils will carry and dissolve more of the oil-soluble HSPA Activator than will Diesel oil. Several new CADE formulations have been developed and released: ARCADE, AIRCADE, and Blending CADE.

NEW EMULSIFYING AGENTS AVAILABLE TO INDUSTRY

E50 Emulsifier: E50 Emulsifier is a soft, light, buff-colored paste, similar in appearance to Wetting Agent 2–7–R. It is miscible in a given amount of water and, in less than an hour of stirring, one 400-pound drum of E50 will produce 228 gallons of a stock solution which, to date, has been found better and cheaper than any other compound of this type for preparing CADE, for introducing its required wetting properties, or for processing Penite.

The bonding of oil and water with E50 is so stable and persistent that it makes possible the development of an entirely new series of considerably more potent CADEs in which the increased potency has been divided between the oil and water phases of the emulsion.

Unlike 2–7–R, E50 is definitely not miscible with water in any proportion. At a concentration of 1¾ pounds paste per gallon of solution, E50 disperses perfectly as a clear colloid which, for all practical purposes, may be stored and processed as any true chemical solution. It should be noted, however, that E50 does react with sodium TCA, whereas 2–7–R tolerates that chemical.

Ultrawet K: Ultrawet K is a dry, granular alkyl aryl type of emulsifying agent. This new product has the advantage of being practically anhydrous and can, therefore, be transported at lower cost than other emulsifiers of this type because it lacks the usual water fraction.

Ultrawet K will produce a satisfactory Paddle CADE when used as a replacement for other types of emulsifying agents now generally employed. However, a stable stock solution in water will not carry more than one pound of the chemical per gallon of solution. Nor is this emulsifying agent as effective as E50 for producing a stable CADE when chemical amendments are added to the oil phase of the emulsion. It has also been found to react with the constituents of Concentrate 40, except when this concentrate is diluted to 20 volumes or more for application in the field.

CHEMISTS LOOK AT CMU

The dispersion of CMU in CADE has proven an excellent method of obtaining the uniform distribution of this herbicide in field application. When properly combined with CADE, CMU will remain in almost perfect suspension for a week or longer.

The compound is processed into a semi-fluid paste before it is added to the CADE pre-mix in a tank above the homogenizer, where it is constantly stirred by a Lightning mixer. The entire mass is then passed through the homogenizer at a pressure of 1500 psi. The final product carries 20 pounds of CMU per 100 gallons.

Permission to use CMU on food crops was suspended early this year by the Production and Marketing Administration in Washington. Their principal concern seems to be the possible carry-over of toxicity into any crop grown on treated soil. Experience has shown that this effect may occur with any chemical or biological modification in the soil. The matter of drift in the application of CMU is also being given serious consideration.

In the interim, however, the compound is being sold as a soil sterilant to railroads, utilities and industrial organizations.

A preliminary pot study was made to determine the residual effect of CMU applied to a cropped soil. Seven months after the original test, the same pots were replanted to weeds and cane, without adding more CMU. The resulting growth gave no indications of differences that could be attributed to the residual effect of the CMU applied up to 30 pounds per acre. In the original experiment, applications of 30 pounds of CMU per acre, and higher, resulted in dead cane and sterile soil.

It appears probable that, under favorable conditions, the persistence of CMU in cropped soils may be reduced either by deterioration in the soil or by leaching, or by a combination of both factors. Additional experiments are being carried out to determine the extent of CMU deterioration in soils and of loss by leaching.

Several members of the research staff of the du Pont Company arrived in Honolulu the latter part of July to conduct research studies on CMU. With headquarters at the University of Hawaii, they hope to obtain analytical data that will satisfy the Production and Marketing Administration concerning the movement and persistence of CMU in soils supporting a crop of sugar cane, and to amass information that will be beneficial to the sugar industry as well as to themselves. The Experiment Station is cooperating in providing satisfactory cane and soil samples from CMU experimental plots for analysis.

TCA STUDIED FOR VARIATIONS IN QUALITY AND COLOR

During the year, several plantations have complained of the seemingly poor quality and the variation in color of a certain brand of sodium TCA. Both the manufacturer and the local distributor were consulted and assurances were received that the product is entirely up to specifications and that the color variations have no effect on the TCA quality. In view of the strict Federal regulation, the TCA content of this herbicide may be confidently assumed to be within specifications.

Some laboratory tests were made on the water-insoluble, inert fraction of the TCA in question. It appears to consist of metallic hydroxides which, on a moisture-free basis, represent less than one per cent by weight of the product. However, when processed into a 2-pound per gallon solution, this fraction expands and the aqueous dispersion of the precipitate occupies about 10 per cent by volume of the solution. This expansion may be responsible for the clogging of strainers reported by some users.

STATION'S TCA INHIBITOR OF CORROSION PROVES OUTSTANDING

Several brands of sodium TCA are being employed by plantations in weed and grass control. Although the manufacturers have added inhibitors of corrosion, their effect appears inadequate to prevent corrosion of equipment, which remains a serious problem.

The Chemistry Department has developed an inhibitor stock solution that may be used with every type of TCA. Tests conducted on several plantations have shown that when TCA solutions were treated with the HSPA inhibitor of corrosion, there was little or no rusting or corrosion of the metal storage containers. However, when this inhibitor was not used, there was severe rusting and pitting of the drums, both above and below the liquid levels.

In view of the favorable reports received from plantations conducting these cooperative tests, application for a patent covering the HSPA inhibitor of corrosion for TCA has been made.

NEW HERBICIDES GIVEN CLOSE SCRUTINY

Through the cooperation of several mainland manufacturers, small quantities of the following chemicals have been made available for our experimental study:

Microsized 2,4–D acid
Microsized ethanol of SES
Microsized benzoate of SES.

The properties of these new chemicals and the manner of employing them are similar to the desirable physical characteristics of CMU and to its use. They are not soluble in water but dissolve slowly in the soil solution, and they are capable of being suspended in a CADE-like emulsion to a uniform and stable mixture.

In using these new chemicals, all of which are free from any volatile components, the danger of vapor drift, harmful or otherwise, is reduced to a minimum. Damage from mechanical drift should also be less likely because of their slow rate of solubility. This research is continuing.

PADDLE-TYPE SES EMULSION FORMULATED

Early in 1952, at the request of one of the plantations, the Chemistry Department developed a formulation of paddle-type SES emulsion which avoids the use of 2,4–D as such, but carries a comparable equivalent. Eleven gallons of this emulsion will carry 6½ gallons of a mixture of equal volumes of 4470 and 4080 oils and 2½ pounds of SES. It may be diluted with water at the rate of 1 to 1, or more. The diluted spray should be applied within a few hours.

MCP EFFECTIVE SUBSTITUTE FOR 2,4–D

Tests have shown MCP to be equal in effectiveness to 2,4–D at equal dosages but not any more effective as a pre-emergence weed control herbicide in sugar cane fields.

OXALIS PROBLEM ATTACKED AT WAIALUA

In a study of Oxalis control at Waialua, it was found that the most effective way to attack this problem was by sprays of low dosage repeated at close intervals. Where one pound of 2,4,5–T per acre was applied weekly for four consecutive weeks, the *Oxalis Martiana* Wood Sorrel was almost completely destroyed. Applications of 2,4–D at the same intervals and dosages were not effective. Single applications of five pounds 2,4,5–T and of 25 pounds 2,4–D were ineffective.

The problem is one of translocating sufficient chemical through a very tender leaf petiole to build up a lethal level in the roots and bulbs without destroying the transporting tissue. This same principle may be effective in other species as well.

WEED LOG PROPOSED FOR EVALUATING CONTROL PROGRAM

A method for logging and forms for recording the complete weed control program in any field, or for comparing two or more types of weed programs on plantation field scale, have been completed. The method and the forms were given to the Island Representatives for distribution to plantations.

SCREENING TESTS FOR PRE-EMERGENCE WEED CONTROL

Several routine pot tests using new chemicals for pre-emergence weed control were conducted at Makiki.

Test No. 45.10, using forms of 2,4–D for pre-emergence weed control at 2.5 pounds in 15 gallons per acre, compared with the check amine concentrate, hammer milled and microsized 2,4–D. None of these treatments was successful at the concentrations used. When these treatments were repeated later in the season, results were no better.

Test No. 45.11 compared four oils for pre-emergence weed control. The materials listed were applied as straight oil at 30 gallons per acre:

1. 4060	3. 4470	5. None
2. 4080	4. 52655–AR	

Results indicate that 4080 oil maintained control of all weeds for one month. At the end of that same period, the other three treatments were ineffective.

FIELD TESTING DURING 1952

The main objective in the field testing program this year was the large-scale evaluation of CMU and of several new CADEs. Several other compounds, such as MCP, 2,4,5–T, SES, and various oils were included.

Sixty-four field tests were conducted cooperatively by the plantations, the Island Representatives, and the Department of Agronomy.

CMU AND 2,4–D: In three tests, CMU applied in CADE substantially increased the period of control over CMU applied in water. In five tests, CMU and 2,4–D were practically equal when compared at the same dosages.

In 19 out of 26 tests, the days of effective control increased with an increase in dosage of CMU.

In nine out of 15 tests, CMU at 2.5 pounds per acre increased by one to 34 the number of days of effective control over that given by an equal dosage of 2,4–D. In four out of 15 tests, 2,4–D was ahead of CMU by from 11 to 18 days.

Out of 26 tests, the longest periods of control for 2.5 and 5.0 pounds of CMU per acre were 83 and 134 days respectively. The shortest periods of control for these dosages were 7 and 10 days respectively. The longest period of control for 2.5

Figure 55. Shown here is the control given by pre-emergence treatments with four pounds of CMU per acre applied in water spray. This picture was taken approximately four months after spraying.

Figure 56. Shown here is the control given by pre-emergence treatments with five and three pounds of 2,4-D per acre. This picture was taken approximately four months after spraying.

pounds of 2,4–D was 58 days, and the shortest was 6 days. (See Figures 55 and 56)

CADEs: According to the number of days of effective weed control recorded, AIRCADE is slightly more effective than ARCADE.

Neither of these two new CADEs gave a substantial increase in the period of control over that given by regular CADE either applied straight or as a 1-in-4 mix.

The main exception to this generality came at Laupahoehoe when AIRCADE gave 14 days control and Poly AIRCADE gave 16 days control. None of the other forms of CADE gave satisfactory control.

The period of effective control by the CADEs was about the same under conditions of heavy rainfall at Hakalau as under irrigated conditions at Oahu Sugar.

WOODY PLANT CONTROL DEMONSTRATED COOPERATIVELY

The Experiment Station, HSPA, the Hawaii Agricultural Experiment Station and the Agricultural Extension Service of the University of Hawaii, and Pacific Chemical and Fertilizer Company, cooperated on a woody plant control project for which nine tests were set up and 10 demonstrations were given on the islands of Hawaii, Kauai, Maui, Molokai and Oahu.

The demonstrations were generally well attended and aroused a good deal of interest, not only among plantation personnel and farmers, but among ranchers and utility companies.

Full data on the tests will be collected, coordinated and studied.

A jeep spray unit and a demonstration are shown in Figures 57 and 58.

TREE AND BRUSH KILLER PROVED EFFECTIVE

A Three-Hormone Tree and Brush Killer, developed by the Chemistry Department early in 1950, was designed to carry, in one formula, low-volatile esters of 2,4–D, 2,4,5–T and TCA. Experimental studies have since been carried out by ranch workers, foresters, plantation agriculturists, and this Station. The results indicate that this formulation is not only effective in tree and brush control, but, since the esters employed are of the type that are considerably less volatile than those formerly used, it has caused little or no damage to nearby vegetation.

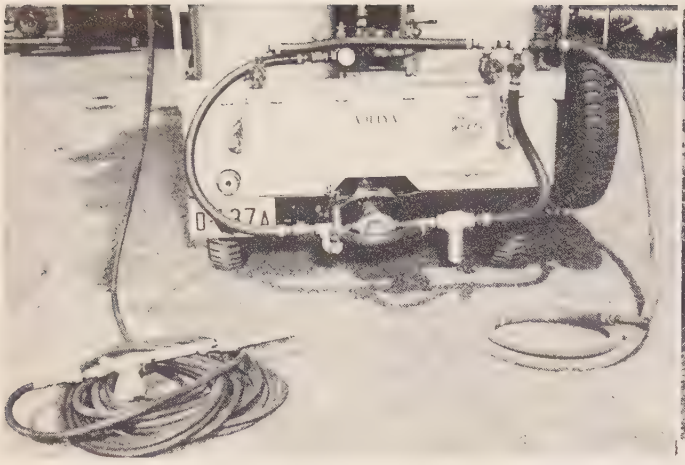


Figure 57. This jeep spray unit was used in the cooperative woody plant control demonstrations. Note the arrangement of the pump, tanks and fittings. The hose on the right is intake for filling drums. That on the left is for delivery of spray.

Figure 58. Woody plant spraying is demonstrated at Grove Farm. Ranchers and plantation men from all of Kauai were present for the 'Field Day'. The use of various kinds of equipment for dispersing both foliage and basal sprays was demonstrated.

Figure 59. This single cyclinder stainless steel pressure knapsack was built by the Sasaki Welding Shop in cooperation with this Station. The tank has a 4-gallon capacity, with air head for dispersing liquid. Note fittings at top and bottom. This unit is fitted for the Pioneer type of two-gun spraying in which the operator walks in the row and sprays both sides.

Figure 60. This stainless steel double knapsack was built by the Sasaki Welding Shop in cooperation with this Station. The total two-tank capacity is five gallons, with air head in each tank for dispersal of spray by the three-nozzle head.

Figure 61. The "Master" control valve for use on tractor sprayers has a built-in pressure regulator. By rotating the lever, any or all sections of the boom can be turned on. At the right, the operator of the Hakalau broadcast tractor demonstrates how sections of the boom can be used independently.

SPRAY EQUIPMENT DEVELOPMENTS IN HAWAII

Two new pressure knapsacks were developed by the Sasaki Welding Shop in cooperation with this Station. One is a single-cylinder stainless steel tank, and the other is a double-cylinder stainless steel unit. (Figures 59 and 60)

Cooperation was given to Hutchinson in the development of a new three-tank pressure knapsack consisting of three 500 cubic inch oxygen tanks.

A Master Control Valve manufactured by the Century Manufacturing Company of Cedar Rapids, Iowa, was tested on the Hakalau broadcast tractor. (Figures 61 and 62)

Cooperative studies have continued in the use of high clearance D–2 tractors for interline spraying at Onomea and Hakalau.

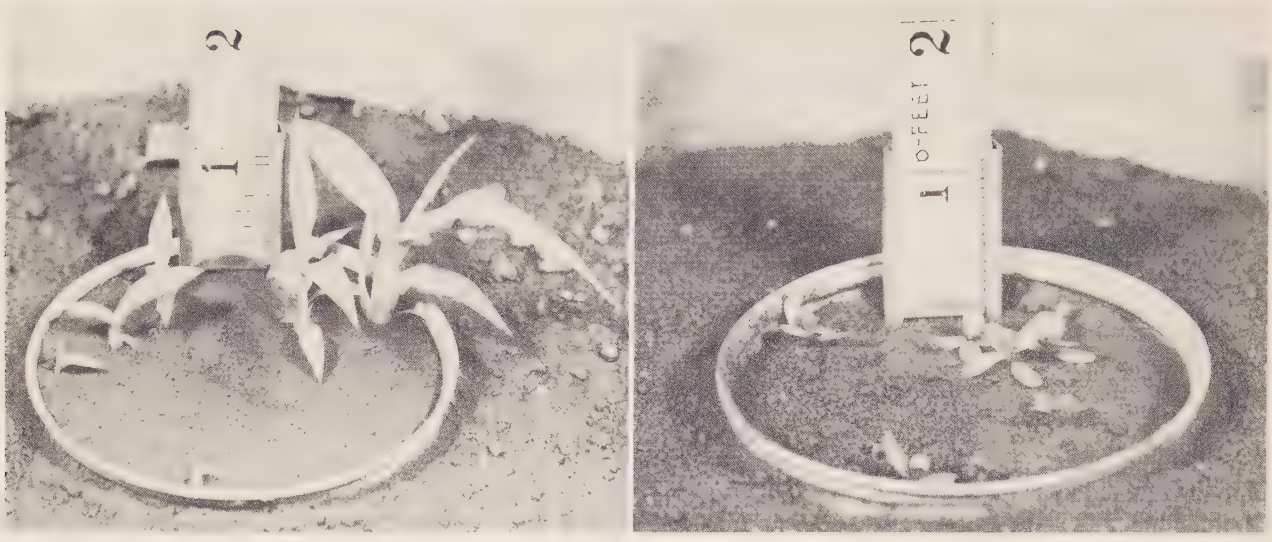


Figure 62. Weed seedling identification is being studied through photographs taken at four stages of plant growth: seed, seedling, vegetative, and mature. These photographs will be used by plantation men in their weed control programs, since seedling identification is extremely important in the present day spray programs. On the left, the seedling stage of bristly foxtail is shown. On the right, the seedling stage of purslane.

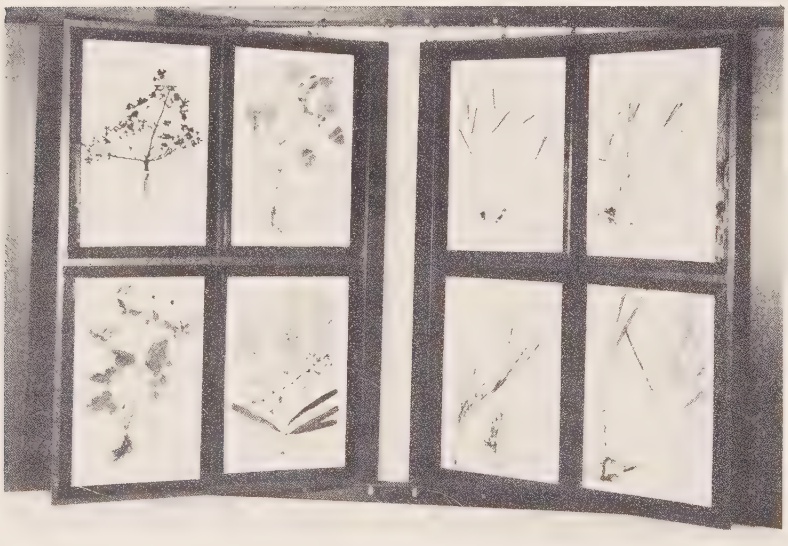


Figure 63. The wall panels in the Department of Training Personnel contain specimens of weeds which have been collected, pressed, mounted, and identified by the Trainees as a permanent exhibit for study and reference.

FOLDER FOR WEED IDENTIFICATION BEING ASSEMBLED

For use by plantation personnel, material is being gathered for a proposed loose-leaf folder showing photographs of sugar cane field weeds in four stages of growth. As far as possible, this folder will contain recommendations for the control of each weed.

For this project, between 80 and 100 photographs have been completed. Figure 63 shows the seedling stages of bristly foxtail and purslane.

The members of the Training Personnel program, under the supervision of the Department of Agronomy, are making a permanent collection of weed specimens to be used for training purposes. Each trainee is assigned to collect, press, mount and properly identify two species. The mounted specimens are then placed in wall panels which have been prepared to house them as shown in Figure 64.

MISCELLANEOUS

NEW RODENTICIDE SHOWS PROMISE IN RAT CONTROL

"Tomorin", a new experimental rodenticide, has been tested in cage studies and has given results equal to those shown by Warfarin. Albino and wild Norway rats eat 20 to 24 per cent of their body weight of the Tomorin poisoned bait and live an average of five to six days before dying. Slightly less toxicity was observed with *Alexandrinus* and *Hawaiiensis* rats, and further testing with these species is in progress.

Tomorin looms as a definite competitor of Warfarin in rat control, and the number of new chemicals in the screening program indicates there will be others.

Figure 64. Assistants-in-Training in Sugar Factory Technology, 1952-1954. From left to right: John W. Herkes, Stanley T. Ooka, Richard G. James, Takuzo Inouye, William R. Wright.

Figure 65. Assistants-in-Training in Agriculture, 1952-1954. From left to right: Alec G. Rogers, Charles H. Bond, James D. Gardner, Tokuwo Kono, Horace F. Clay, Milton P. Sideris, Paul R. Van Zwaluwenburg, William J. Crittenden, Ronald J. Winans.

STATION PERSONNEL CHANGES IN 1952

JOINED THE STAFF

Amerino, Raymond C.	Dairyman	By-Products
Arakaki, Takako	Laboratory Helper	Sugar Technology
Baba, Eli H.	Laboratory Helper	Sugar Technology
Bond, Charles H.	Assistant-in-Training	Training Personnel
Brosnan, Shirley G.	Stenographer	Agronomy
Brown, Robert L.	Laboratory Technician	By-Products
Bumanglag, Elena C.	Typist-Clerk	Oahu Substation
Chun, Kenneth K. L.	Machinist	Agricultural Engineering
Clay, Horace F.	Assistant-in-Training	Training Personnel
Crittenden, Wm. J.	Assistant-in-Training	Training Personnel
Doyle, Bascom K.	Livestock Nutritionist	By-Products
Fernandez, Domingo P.	Janitor	Makiki Buildings & Grounds
Flores, Julian R.	Janitor	Makiki Buildings & Grounds
Gahes, Pantaleon G.	Janitor	Makiki Buildings & Grounds
Gardner, James D.	Assistant-in-Training	Training Personnel
Herkes, John W.	Assistant-in-Training	Training Personnel
Ho, Edward Y. T.	Laboratory Helper	By-Products
Hoshide, Dorothy	Clerk	Kauai Substation
Inouye, Takuzo	Assistant-in-Training	Training Personnel
James, Richard G.	Assistant-in-Training	Training Personnel
Katano, John K.	Laboratory Helper	By-Products
Knapp, Samuel B.	Associate Pulp and Paper Technologist	By-Products
Kono, Takuwo	Assistant-in-Training	Training Personnel
Lambert, George E.	Instrument Technician	Meteorology
Lizardo, Estanislao P.	Cowboy	By-Products
Maeda, Melvin T.	Assistant Carpenter	Makiki Buildings & Grounds
Mahoe, Charles K.	Mechanic	Agricultural Engineering
Matsuoka, Shigeo	Machinist	Agricultural Engineering
Mendoza, Alejandro P.	Janitor	Makiki Buildings & Grounds
Mendoza, Narciso L.	Janitor	Makiki Buildings & Grounds
Mink, John F.	Drafting Helper	Geology
Miura, Arthur S.	Laboratory Helper	Pathology
Miyashita, Marion	Typist	Agronomy
Murashige, Bert Y.	Drafting Engineer	Geology
Murashige, Toshio	Agronomy Assistant	Agronomy
Nutter, James M.	Assistant Agricultural Engineer	Agricultural Engineering
Ooka, Stanley T.	Assistant-in-Training	Training Personnel
Robinson, Wm. A.	Senior Pulp and Paper Technologist	By-Products
Rogers, Alec G.	Assistant-in-Training	Training Personnel
Sideris, P. Milton	Assistant-in-Training	Training Personnel
Sodetani, Katsumi	Laboratory Helper	By-Products
Tempas, Walter J.	Assistant Agricultural Engineer	Agricultural Engineering
Tumamao, Pedro C.	Cowboy	By-Products
Van Zwaluwenburg, Paul	Assistant-in-Training	Training Personnel
Wilson, Andrew J.	Assistant Technologist	Sugar Technology
Winans, Ronald J.	Assistant-in-Training	Training Personnel
Wright, Wm. R.	Assistant-in-Training	Training Personnel

LEFT THE STAFF

Amerino, Raymond C.	Dairyman	By-Products
Blanshine, Allison W.	Senior Agricultural Engineer	Agricultural Engineering
Brown, Robert L.	Laboratory Technician	By-Products
Carias, Vincent C.	Machinist	Agricultural Engineering
Deacon, James E.	Assistant-in-Training	Training Personnel
Domingsil, Noberto	Janitor	Makiki Buildings & Grounds
Doty, Wallace L., Jr.	Assistant-in-Training	Training Personnel
Fairchild, Wm. D.	Assistant-in-Training	Training Personnel
Flores, Julian R.	Janitor	Makiki Buildings & Grounds
Higashiyama, Henry K.	Assistant-in-Training	Training Personnel
Hirakawa, Gotaro	Janitor	Makiki Buildings & Grounds
Ho, Edward Y. F.	Laboratory Helper	By-Products
Hoshide, Dorothy	Clerk	Kauai Substation
Hosokawa, Zenjiro	Janitor	Makiki Buildings & Grounds
Kahlbaum, Paul O.	Assistant-in-Training	Training Personnel
Larsen, Jack L.	Assistant-in-Training	Training Personnel
McCorriston, Florence M.	Clerk-Typist	Agronomy
Murashige, Bert Y.	Drafting Helper	Geology
Murashige, Toshio	Agronomy Assistant	Agronomy
Sakaue, Robert S.	Laboratory Helper	Pathology
Shigeta, Goro	Janitor	Makiki Buildings & Grounds
Street, Charles G. Jr.	Assistant-in-Training	Training Personnel
Suzuki, Thomas	Laboratory Helper	By-Products
Tumamao, Pedro C.	Cowboy	By-Products
Wilson, Andrew J.	Assistant Technologist	Sugar Technology

ON LEAVE OF ABSENCE FOR MILITARY DUTY

Ballinger, Donald K.	Assistant-in-Training	Training Personnel
Imamura, Robert	Field Helper	Genetics
Lee, Dennis K. P.	Drafting Helper	Geology
May, C. W., Jr.	Assistant-in-Training	Training Personnel
Nakamura, Robert	Laboratory Assistant	Physiology & Biochemistry
Nelson, Victor J.	Assistant-in-Training	Training Personnel
Palmer, Marshall T.	Assistant-in-Training	Training Personnel
Ogasawara, Edwin T.	Assistant-in-Training	Training Personnel
Sakai, Richard H.	Office Helper	Business Office
Shiosaki, James	Field Helper	Genetics
Takajo, Mareo	Machinist	Agricultural Engineering
Takakawa, Roy M.	Laboratory Helper	Publications & Visual Aids
Tamura, Harold	Laboratory Helper	Chemistry
Vorfeld, Robert T.	Assistant-in-Training	Training Personnel